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REPORT OF THE SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES ON

Assessment of Mediterranean Sea stocks

(STECF 12-03)

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This report was reviewed by the STECF during its 39th plenary meeting

held from 16 to 20 April, 2012 in Brussels, Belgium

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TABLE OF CONTENTS

SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF)

Assessment of Mediterranean Sea stocks - part 3 (STECF 12-03)

THIS REPORT WAS ADOPTED DURING THE PLENARY MEETING HELD IN BRUSSELS 16- 20 April 2012

Request to the STECF

STECF is requested to review the report of the **EWG 11-20** held from 16 – 20 January in Madrid, Spain, to evaluate the findings and make any appropriate comments and recommendations.

Introduction

The report of the Expert Working Group on Assessment of Mediterranean Sea stocks - part 3 (STECF EWG 11-20) was reviewed by the STECF during the plenary meeting held from 16 to 20 April, 2012 in Brussels, Belgium. The following observations, conclusions and recommendations represent the outcomes of that review.

STECF observation

The EWG 11-20 assessed the status of 10 demersal stocks and 3 small pelagic fish stocks and their fisheries. The assessments of recent and historic stock parameters and fisheries as well as management advice provided in the EWG 11-20 report were limited to Geographical Subareas (GSAs) off France, Greece, Italy and Spain. Together with the previous two Mediterranean EWG meetings held in 2011 (EWG 11-05 and EWG 11-12), 42 assessments or reviews of assessments were conducted in total, of which 37 assessments resulted in an estimate of current exploitation rate that was evaluated against the proposed F_{MSY} reference point. The results presented in the reports of the EWG 11-05, 11-12 and 11-20 represent the best available estimates of current exploitation status for the demersal and small pelagic stocks in the Mediterranean Sea.

The EWG 11-20 also carried out short-term and medium term forecasts of stock size and yield for 26 stocks, assessed mostly during the previous EWG meetings in 2011, for which the assessments of historic stock parameters supported such analyses. The simulated scenarios, which incorporate politically-agreed management targets (Johannesburg summit & MSFD), were as follows:

- Short-term forecasts of catch and biomass for 2012 assuming different levels of F (from 0 to two times the current F and including F_{MSY})

- Medium term forecasts of annual catch and biomass assuming:
  - (a)Constant $F = F_{MSY}$ until 2020
  - (b) 10% reduction in F each year until 2020 (GFCM, 2009)
  - (c)Hit $F = F_{MSY}$ by 2015, then fix $F = F_{MSY}$
  - (d) Linear decrease in F to hit $F = F_{MSY}$ in 2020

A general observation is that assuming constant recruitment, under all medium term scenarios spawning biomass and catches are predicted to increase in the medium term, particularly under scenarios (a) and (c). However under scenarios (a) and (c) catches are predicted to decrease in the short-term. It is also important to note that the catches from most stocks in the Mediterranean are highly dependent on recruitment since catches consist mostly of juveniles.

The Report of the EWG 11-20 provides detailed stock summary sheets which include an assessment of exploitation status relative to proposed management reference points for fishing mortality, which in most cases is the value of F corresponding to $F_{0.1}$ (a proxy for F_{MSY}). Stocks were classified as being subject to overfishing when the estimate for fishing mortality was higher than the proposed F_{MSY} reference point. Stocks were classified as being sustainably exploited when estimated F is equal to or below the relevant F_{MSY} reference point.

The EWG 11-20 also examined the completeness and quality of the data obtained through the DCF data call in 2011. The most recent data available during the meeting included those of 2010. The major issue that had to be addressed by the EWG was that many Member States had significantly revised their landings and effort figures for the whole time series requested. Furthermore, MEDITS survey information was not available for many GSAs for 2010 and 2011. These data are required to provide input to short-term forecasts.

Finally, during the EWG 11-20 meeting, two Mediterranean Management Plans were evaluated; the Spanish fisheries management plan in Mediterranean waters for the period 2012-2016 and the Slovenian fisheries management plan for the period 2011-2013. The STECF review of the report on the Spanish and Slovenian management plans was undertaken intersessionally and adopted by written procedure in February 2012 (STECF OWP 12-02[1]).

STECF conclusions

According to the results of the assessments presented in the report of the STECF-EWG 11-12, STECF concludes that the following stocks are subject to overfishing:

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[1] https://stecf.jrc.ec.europa.eu/reports/management-plans

- European hake (*Merluccius merluccius*) GSAs 5, 7 10, 11 and 18
- Red mullet (*Mullus barbatus*) in GSAs 7, 10 and 11
- Stripped red mullet (*Mullus surmuletus*) in GSA 5
- Pink shrimp (*Parapenaeus longirostris*) in GSA 10
- European sardine (*Sardina pilchardus*) in GSA 22

STECF concludes that the following stocks are being exploited sustainably:

- Anchovy (*Engraulis encrasicolus*) in GSA 22
- European sardine (*Sardina pilchardus*) in GSA 17

STECF recommendations

Given that 95% of the demersal and small pelagic stocks in the Mediterranean assessed by STECF in 2011 (Reports of EWG 11-05, EWG 11-12 and EWG 11-20 meetings) were classified as being subject to overfishing, STECF recommends that, in order to avoid future losses in stock productivity and landings, fishing mortality should be reduced to reach the proposed F_{MSY} reference points.

Expert Working Group report

REPORT TO THE STECF

EXPERT WORKING GROUP ON Assessment of Mediterranean Sea stocks - part 3 (STECF EWG 11-20)

Madrid, Spain 16-20 January 2012

1 EXECUTIVE SUMMARY

The STECF Expert Working Group 11-20 met in Madrid (Spain) from 16 to 20 January 2012 to continue STECF efforts regarding its mandate for Mediterranean stock and fisheries assessments. The meeting was chaired by Massimiliano Cardinale and attended by 19 experts in total, including 4 STECF members, 3 JRC experts. In addition, one observer from the Regional Advisory Council for the Mediterranean (RAC MED) joined only one morning session.

The major ToRs (A-E), the assessment of 13 Mediterranean exploited stocks and fisheries, was addressed by using the provided data through DCF data call for the Mediterranean issued to Member States on 3 August 2011 with deadlines on 2 September 2011 and 1 December 2011. The latter deadline had been specifically set to call for in-year survey results (2011) to improve the precision of short term forecasts of stock size and catch opportunities under various management scenarios in 2012.

The assessments of recent and historic stock parameters and fisheries as well as management advice provided in the present report is constrained for the Geographical Subareas (GSA) off France, Greece, Italy and Spain. Other stocks have been subject to assessment during previous meetings (EWG 11-05 and EWG 11-12). The assessments of exploited stocks and fisheries estimated the stocks' exploitation status which was evaluated against the proposed F_{MSY} limit.

Under ToRs F, the EWG 11-20 focused on the short term, medium term and long term forecasts of stock size and yield for 26 stocks, assessed mostly during the previous EWG meetings in 2011, where the assessments of historic stock parameters supported such analyses. The different simulated scenarios covered the politically agreed management targets to maintain or achieve sustainable exploitation in 2012, by 2015, 2020 or through a reduction of fishing effort by 10% applied to all demersal fisheries (as established by the GFCM resolution in 2009).

ToRs G addressed the adjustements of data needs and quality for Mediterranean stocks fisheries and surveys in the 2012 DCF.

ToRs H covered the evaluation of the Spanish fisheries management plan (MP) in Mediterranean waters for the period 2012-2016 and the Slovenian fisheries management plan.

The EWG 11-20 discussed relevant topics for the following-up EWG meetings within the STECF framework and logistics in 2012.

2 CONCLUSIONS OF THE WORKING GROUP

ToR A-E update and assess historic and recent stock parameters: The EWG 11-20 assessed the status of 10 demersal stocks and 3 stocks of small pelagic species and their fisheries. Together with the two previous meetings in 2011, 42 assessment were conducted, of which 37 assessments or reviews of assessments resulted in an estimate of the exploitation rate. Around 95% of stock assessed are classified as being subject to overfishing, while 2 stocks were assessed to be sustainably exploited (Annex II). The assessment of 1 stock did not result in a conclusion regarding their exploitation status due to data deficiencies.
The EWG 11-12 could provide for the assessed stocks detailed summary sheets informing about the stocks' status and their state of exploitation in relation to proposed management reference points consistent with high long term yields (F_{MSY}).

The STECF EWG 11-20 concludes that the:

- **two** stocks in GSA 5, European hake (*Merluccius merluccius*) and stripped red mullet (*Mullus surmuletus*) are subject to overfishing
- **two** stocks in GSA 7, European hake (*Merluccius merluccius*) and red mullet (*Mullus barbatus*) are subject to overfishing
- **two** stocks in GSA 11, European hake and red mullet are subject to overfishing
- **three** stocks in GSA 10, European hake, red mullet and pink shrimp (*Parapenaeus longirostris*) are subject to overfishing
- **one** stock of European hake in GSA 18 is subject to overfishing
- **one** stock of Sardine (*Sardina pilchardus*) in GSA 22 is subject to overfishing
- **one** stock of anchovy (*Engraulis encrasicolus*) in GSA 22 is sustainably exploited
- **one** stock of Sardine in GSA 17 is exploited sustainably
- stock of anchovy in GSA 17 could not be assessed due to data limitations

ToR F Short term, medium term and long term forecasts of stock size and yield: The EWG 11-20 conducted deterministic short term and stochastic medium term forecasts of stock size and catch where the assessments of historic stock parameters supported such analyses for 26 different stocks. The different scenarios covered the politically agreed management targets to maintain or achieve sustainable exploitation in 2012, by 2015, 2020 or through a reduction of fishing effort by 10% applied to all demersal fisheries (as established by the GFCM resolution in 2009).

ToR G DCF data call: The EWG discussed the completeness and accuracy of the data obtained during the DCF Mediterranean data call in 2011 in different GSAs.

ToR H Assessment of fisheries management plan submitted by Spain and Slovenia: Conclusions are published in the STECF OWP 12-02 after being reviewed by STECF by written procedure.

Future planning of Mediterranean expert group meetings: The expert working group received an invitation by IFREMER to host its follow-up meeting EWG 12-10 Mediterranean assessments part 1 from 16 to 20 July 2012 in Sete (France). The venue of the second meeting EWG 12-19 will be held from 10 to 14 December and it has been provisionally planned to be convenend in Ancona (Italy).

3 RECOMMENDATIONS OF THE WORKING GROUP

ToR A-E update and assess historic and recent stock parameters: The EWG 11-20 highly recommends the reduction of the effort of the relevant fleets' catching the following stocks until fishing mortality is below or at the proposed level F_{MSY}, in order to avoid future loss in stock productivity and landings: European hake (*Merluccius merluccius*), in GSA 05, GSA 07, GSA 10, GSA 11 and GSA 18, red mullet (*Mullus barbatus*) in GSA 07, GSA 10 and GSA 11, striped red mullet (*Mullus surmulletus*) in GSA 5, pink shrimp (*Parapaeneus longirostris*) in GSA 10 and the Sardine (*Sardina pichardus*) in GSA 22. This target should be reached by means of a multi-annual management plan taking into account mixed-fisheries effects. Catches and effort consistent with F_{MSY} should be estimated.

ToR F: No specific recommendations.

ToR G: EWG 11-20 recommends the different MS to agree on a harmonized time period required for data to be available for transmission to end-users. EWG 11-20 suggests, for all transversal and biological data collected, a time period of 6 months following the last day of the collection of data (i.e. last survey day or last calendar day for landings data); this time period should be respected by the data calls and the end users.

ToR H Assessment of fisheries management plan submitted by Spain and Slovenia: no recommendations.

Future planning of Mediterranean expert group meetings: The next STECF expert meeting (EWG 12-10: Assessment of Mediterranean Sea stocks - part 1) will be convened on 16-20 July 2012 in Sete, France.

4 INTRODUCTION

The expert working group on Mediterranean stock and fisheries assessment STECF EWG 11-20 held its third out of three meetings planned in 2011 in Madrid, 16-20 January 2012. The meeting was originally arranged to be held during the week 12-16 December 2011 but has been postponed by the STECF bureau to January 2012.

The chairman opened the meeting at 9.00 am on Monday, 16 January 2012, and adjourned the meeting by 4.00 pm on Friday, 20 January 2012. The meeting was attended by 19 experts in total, including 4 STECF members and 3 JRC experts. One observer representative of the Regional Advisory Council for the Mediterranean (RAC MED) attended the Thursday morning session.

The structure of the present report is in accordance with the terms of reference to STECF, as defined in the following chapter.

4.1 Terms of Reference for the STECF EWG 11-20

The STECF is requested to

a) update and assess historic and recent stock parameters for the longest time series possible of the species listed below by GSAs or combined GSAs and parameters of their fisheries (by fleets) in the Mediterranean Sea, with emphasis on stocks previously assessed analytically. Assessment data and methods are to be fully documented with particular reference to the completeness and quality of the data submitted by Member States as response to the official Mediterranean DCF data call issued on August 2011. To the extent possible, the assessment shall provide the target (biological, bio-economic), the precautionary (threshold) and conservation (limit) reference points, either model based or empirical. Data collected outside the DCF and/or delivered to the meeting by non-EU scientists shall be used as well and merged with DCF data whenever appropriate. Due account shall also be given to data used and assessments carried out within the FAO regional projects co-funded by the European Commission and EU-Member States in particular when using data collected through the DCF/DCR, EU funded research projects, studies and other types of EU funding.

- Sardine (*Sardina pilchardus*)
- Anchovy (*Engraulis encrasicolus*)
- European hake (*Merluccius merluccius*)
- Common sole (*Solea solea*)
- Red mullet (*Mullus barbatus*)
- Deep-water rose shrimp (*Parapenaeus longirostris*)
- Red shrimp (*Aristeus antennatus*)
- Giant red shrimp (*Aristaeomorpha foliacea*)
- Norway lobster (*Nephrops norvegicus*)

b) assess historic and recent stock parameters for the longest time series possible of the species listed Annex 7 of the DCF data call issued on August 2011. Parameters of their fisheries (by fleets) by all relevant individual GSAs in the Mediterranean Sea, or combined GSAs where appropriate, shall be provided as well. Assessment data and methods are to be fully documented with particular reference to the completeness and quality of the data submitted by Member States as response to the official Mediterranean DCF data call issued on August 2011. Data collected outside the DCF and/or delivered to the meeting by non-EU scientists shall be used as well and merged with DCF data whenever necessary. Due account shall also be given to data used and assessments carried out within the FAO regional projects co-funded by the European

Commission and EU-Member States in particular when using data collected through the DCF/DCR and EU funded research projects, studies and other types of EU funding.

- Other species of the Tables 1 and 2 of the official Mediterranean DCF data call issued on 29 April 2010 with particular attention to: Common Pandora (*Pagellus erythrinus*), striped red mullet (*Mullus surmuletus*), bogue (*Boops boops*), sea bass (*Dicentrarchus labrax*), blue whiting (*Micromesistius poutassou*), gilthead seabream (*Sparus aurata*), Blackspot seabream, (*Pagellus bogaraveo*), Poor cod (*Trisopterus minutus*), Sargo breams (*Diplodus spp*), mackerel (*Scomber spp*), spottail mantis squillid (*Squilla mantis*).

c) review of assessments of historic and recent stock parameters of demersal and small pelagic species listed under a) and b) and assessments of their fisheries in the Mediterranean Sea as conducted by other scientific frameworks including also national framework of non-EU countries. Due account shall be given in particular to data used and assessments carried out within the FAO regional projects co-funded by the European Commission and EU-Member States in particular when using data collected through the DCF/DCR and EU funded research projects, studies and other type of EU funding.

d) assess, propose and review biological fisheries management reference points, either model based or empirical, of exploitation and stock size related to high yields and low risk of fishery collapse in long term of each of the stocks listed under a), b) and c) and assessed by STECF or other scientific frameworks. This work shall provide, to the extent possible, the target (biological, bio-economic) for sustainable fishing at MSY or proxy, the precautionary (threshold) and conservation (limit) reference points. Assessment data and methods are to be fully documented with particular reference to the completeness and quality of the data submitted by Member States as response to the official Mediterranean DCF data call issued on August 2011.

e) advise on the recent status of exploitation and stock size of the species listed under a), b) and c) in relation to the biological fisheries management reference points as identified under d).

f) provide short term, medium term and long term forecasts of stock biomass and yield for the stocks assessed during the EWG meetings in 2011 and any updated assessments, under different management options with a view to evaluate the consequences for fishing effort/mortality changes on equivalent time scale, by fishery/métier and fleets (i.e. GSA) where possible. Short, medium and long term forecast scenarios should include:

- the status quo

and

- target to F_{MSY} or other appropriate proxies for 2011, 2015 and 2020, respectively.

The identification and description of the fisheries/métier to be considered are left to the experts on the basis of their knowledge of fisheries in each GFCM-GSA.

The simulation by fishery for the abovementioned targets shall be driven either by the most relevant stock(s) (either in quantity and/or economic value), or the most vulnerable stock or a scientifically weighed mix of MSY targets for the species involved in the fishery.

To advise on stock-size dependent harvesting strategies and slope based approaches decision control rules to avoid risk situations for the stocks while ensuring high fisheries productivity, taking into account the recommendation of the SGMED-09-02 meeting in June 2009 and the subsequent STECF comments with specific attention to small pelagic stocks (STECF-10-03).

Consequences of important by-caught stocks in mixed fisheries should be quantified if possible or at least indicated. Such analyses should fully document all applied methodologies and data used for the projections in accordance with the achievements of SGMED 09-03.

g) review the DCF data call in 2011 for Mediterranean stocks, fisheries and surveys and suggest adjustments on data needs and quality of data called in the DCF in 2012.

h) Assessment of management plan 2011-2015 submitted by Spain and Slovenia

STECF EWG 11-20 is requested to review the scientific basis for management plans as required by the Mediterranean Regulation (C.R. (EC) No1967/2006), to evaluate its findings, to make appropriate comments, also with respect to the elements/measures included in the proposed management plan and to advise whether the plan contains elements that account for:

1. the biological characteristics and the state of the exploited resources with reference in particular to low risk of stock collapse,
2. the fishing pressure and if concerned fisheries are duly described and expected to exploit the main target stocks in line with their production potentials. Advise whether the plan is expected to maintain or to revert fisheries productivity to higher levels in line with MSY or proxy and in which time frame.
3. pre-agreed harvesting control rules based either on catch limitation, fishing pressure or biomass levels
4. impact of fishing activities on marine environment (protected habitats and species)
5. size and/or species selectivity of the regulated fishing gears with particular attention to sizes and relative quantities of species mentioned in Annex III of the Mediterranean Regulation
6. mechanisms of monitoring and review of the plans

Other species of the Tables 1 and 2 of the official Mediterranean DCF data call issued on 29 April 2010.

Table 1: Additional species as included in the data collection regulations.

Species common name, species scientific name FAO CODE

1. Bogue *Boops boops* BOG
2. Common dolphinfish *Coryphaena hippurus* DOL
3. Sea bass *Dicentrarchus labrax* BSS
4. Grey gurnard *Eutrigla gurnardus* GUG
5. Black-bellied angler *Lophius budegassa* ANK
6. Anglerfish *Lophius piscatorius* MON
7. Blue whiting *Micromesistius poutassou* WHB
8. Grey mullets (*Mugilidae*) Mugilidae MUL
9. Common Pandora *Pagellus erythrinus* PAC
10. Caramote prawn *Penaeus kerathurus* TGS
11. Mackerel *Scomber spp.* MAZ
12. Common sole *Solea solea* (=*Solea vulgaris*) SOL
13. Gilthead seabream *Sparus aurata* SBG
14. Spottail mantis squillids *Squilla mantis* MTS
15. Mediterranean horse mackerel *Trachurus mediterraneus* HMM
16. Horse mackerel *Trachurus trachurus* HOM
17. Tub gurnard *Trigla lucerna* (= *Chelidonichthys lucerna*) GUU

Table 2: Additional species not included in the data collection regulations.

Species common name, species scientific name FAO CODE

1. Sargo breams *Diplodus spp.* SRG
2. Axillary seabream *Pagellus acarne* SBA
3. Blackspot seabream *Pagellus bogaraveo* SBR
4. Greater forkbeard *Phycis blennoides* GFB
5. Poor cod *Trisopterus minutus* POD

4.2 Participants

The full list of participants at EWG 11-20 is presented in Annex I to this report.

5 ToR A-E UPDATE AND ASSESS HISTORIC AND RECENT STOCK PARAMETERS (SUMMARY SHEETS)

The following section of the present report does provide short stock specific assessments in the format of summary sheets. Such summary sheets are only provided in cases when the analyses resulted in an analytical assessment of the exploitation rate. Unlike earlier years, the assessments are presented in geographic order by GSA, and not any longer by species. The format of the summary sheet has been agreed by the experts in 2008. Detailed versions of the assessments of stocks and fisheries are provided in the following section 6 of the report.

5.1 Summary sheet of European hake (*Merluccius merluccius*) in GSA 5

Species common name:	European hake
Species scientific name:	*Merluccius merluccius*
Geographical Sub-area(s) GSA(s):	GSA 5

Most recent state of the stock

The assessment of this stock was presented to GFCM meeting held in Crete (Greece) during 24-29 October 2011 (see www.gfcm.org for details).

State of the adult abundance and biomass:

In the absence of proposed and agreed precautionary management reference points EWG-11-20 is unable to fully evaluate the state of SSB. SSB showed important oscillations during the entire time series ranging between 20 and 50 tons throughout the series.

State of the juvenile (recruits):

Recruitment also showed important oscillations during the time series analysed. However, the peaks observed during the 1980s and early 1990s ($6.5\text{-}7.0 \cdot 10^6$) were clearly higher than the peaks observed thereafter. There was a sharp decrease between 1991 and 1994, but recruitment recovered afterwards. With the exception of a maximum of 5.0-5.5 in 2004-2005, values have remained between 1.5 and $4.0 \cdot 10^6$ from 1994 to 2010.

State of exploitation:

Mean fishing mortality over ages 0 to 4 years showed oscillations during the entire data series, although it has been quite stable during the last years (2004-2010). The vector of fishing mortality over ages shows that the highest fishing exploitation is estimated for 1-2 years old individuals and also that the exploitation of recruits (age 0) is very low. The current F_{curr} (1.21) is above the F_{MSY} reference point (0.157), which indicates that hake in GSA 5 is overexploited.

Source of data and methods:

Hake in GSA 5 is only taken by the trawl fishery. Landings time series between 1980 and 2010 are from the bottom trawl fleet of Mallorca (see figure below). Length frequency distributions from monthly on board or on port samplings were obtained. Discards were included in the assessment and were obtained from on board samplings. The biological parameters used for the assessment were the following: 1) growth parameters from Mellon-Duval et al. (2009) (L_{inf}= 110, K= 0.178); 2) length-weight relationships obtained from the Spanish National Data Collection (a= 0.0048, b= 3.12); 3) natural mortality at age calculated using the PROBIOM spreadsheet (Abella et al. 1997); and 4) maturity at age obtained from the Spanish National Data Collection in GSA 5.

Outlook and management advice

The stock status indicators showed that the resource is overexploited (F_{curr}>F_{MSY}). The EWG recommends the relevant fleet's effort to be reduced until fishing mortality is below or at the proposed F_{MSY} level in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects. Catches consistent with the proposed effort reduction should be estimated. Since a part of the catches is under the minimum landing size, the improvement of the trawl exploitation pattern would imply increases in potential landings.

Short, medium and long term scenarios:

To be conducted and delivered by EWG 12-01.

Fisheries

In the Balearic Islands (GSA 5), commercial trawlers employ up to four different fishing tactics (Palmer et al. 2009), which are associated with the shallow and deep continental shelf, and the upper and middle continental slope (Guijarro & Massutí 2006; Ordines et al. 2006). Vessels mainly target striped red mullet (*Mullus surmuletus*) and European hake (*Merluccius merluccius*) on the shallow and deep shelf respectively. However, these two target species are caught along with a large variety of fish and cephalopod species. The Norway lobster (*Nephrops nervegicus*) and the red shrimp (*Aristeus anennatus*) are the main target species on the upper and middle slope, respectively. The Norway lobster is caught at the same time as a large number of other fish and crustacean species, but the red shrimp fishery is the only Mediterranean fishery that could be considered monospecific. Recent annual landings of hake are in the order of 70 tons.

Limit and target management reference points or levels

Table of limit and target management reference points or levels **proposed by EWG 11-20**

E_{lim} (age range)=	
$F_{0.1}$ (0-5)=	0.157
F_{max}=	
F_{msy} (0-5)=	0.157
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and target management reference points or levels **agreed by fisheries managers**

E_{lim} (age range)=	
$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

5.2 Summary sheet of striped red mullet (*Mullus surmuletus*) in GSA 5

Species common name:	Striped red mullet
Species scientific name:	*Mullus surmuletus*
Geographical Sub-area(s) GSA(s):	GSA 5

Most recent state of the stock

The assessment of this stock was presented to GFCM meeting held in Crete (Greece) from 24 to 29 October 2011 (see www.gfcm.org for details).

State of the adult abundance and biomass:

SB (i.e stock biomass) showed a maximum of 555 tons in 2001 and a minimum of 397 in 2009, whereas during the rest of the years the values remained rather constant between 450 and 500 tons. SSB also remained rather constant close to 200 tons during the time series, with the exception of a maximum of 225 tons in 2005 and a minimum of 180 tons in 2009. The SB/SSB relationships also remained rather constant, ranging from 39% in 2000 to 45% in 2009.

State of the juvenile (recruits):

Recruitment showed a clear a decresing trend along the series. The number of recruits decreased from 9.2 to $5.8 \cdot 10^6$ between 2000 and 2009, although it increased again to $7.6 \cdot 10^6$ in 2010.

State of exploitation:

Fishing mortality ranged between 0.46 and 0.72, showing an oscillatory behaviour, with a clear decreasing trend between 2000 and 2004, followed by an increase up to 2007 and another decrease down to 2009. The vector of fishing mortality by age shows that the highest fishing exploitation is suffered by individuals between 2 and 3 years old and also that the exploitation of the recruits (age 0) is very low. The current F_{curr} (0.55) is higher than the F_{MSY} reference point (0.26), which indicates that striped red mullet in GSA 5 is overexploited.

Source of data and methods:

Landings time series from 2000 to 2010 of the two fleets exploiting this species (trawl and small-scale fleet; see figure below). Discards of this species in GSA 5 are negligible (Carbonell et al. 1997).

Length frequency distributions from monthly on port (small-scale) and on board (trawling) samplings developed during the entire time series.

The biological parameters used for the assessment were the following: 1) growth parameters obtained from otholit readings carried out in the framework of the Spanish National Data Collection (L_{inf}= 40.05, K= 0.164, t_0= S1.883); 2) length-weight relationships obtained from the Spanish National Data Collection (a= 0.0084, b= 3.118); 3) natural mortality at age calculated using the PROBIOM spreadsheet (Abella et al. 1997); and 4) maturity at age obtained from the Spanish National Data Collection in GSA 5.

Terminal fishing mortality (Ft) was obtained from the catch curve, using the FLEDA package (Jardim & Azevedo 2004), and adjusted afterwards with a previous VPA followed by a Separable VPA. Different trials were done to obtain the best results from the Separable VPA changing both the reference age and the terminal selection value. The best fit was obtained with a reference age of 2 and a terminal selection value of 0.735. Residuals were always smaller than 1 (most of them <0.5) and did not show any trend throughout the years. Finally, the vector of F by age, including the Ft, obtained with this Separable VPA was used as input parameters.

Maturity, natural mortality and fishing mortality at age

Age	0	1	2	3	4	5
Proportion of matures	0.15	0.39	0.79	0.95	1.00	1.00
Natural mortality (M)	1.0	0.6	0.4	0.3	0.3	0.3
Fishing mortality (F)	0.113	0.441	0.695	0.667	0.555	0.625

XSA tuning were performed using abuncance indices from MEDITS surveys (N/km^2) developed during 2001–2010 around the Balearic Islands and CPUEs of daily landings from the trawling fleet of one port of Mallorca (Santanyí). It was used this port, situated in the SE of the island, because its fleet works basically on the continental shelf, and thus it can be considered that their CPUEs are a good indicator of the species abundance (*Mullus surmuletus* inhabits mainly the shelf). The landings of this port represented 12–30% of the total catch of Mallorca during the assessed period. Abundance indices from surveys were calculated considering different bathymetric strata. For tuning VPA, the values obtained in the stratum corresponding to the continental shelf (<100 m depth) were used because they best reflected the evolution of commercial landings.

Outlook and management advice

Stock status indicators showed that the resource was overexploited (F_{ref}>$F_{0.1}$; $F_{0.1}$=0.26; F_{ref}=0.55). Modal length in GSA 5 (16-17 cm) was well above the length at first maturity (14.2 cm, obtained in the Spanish National Data Collection). It must also be considered that striped mullet in GSA 5 is only caught as a by-catch in the trawl fishery and a management of this species should be undertaken in the framework of a multispecific approach.

<u>Short, medium and long term scenarios:</u>

To be conducted and delivered by SGMED 12-03.

Fisheries

Striped mullet is one of the most important target species in the trawl fishery developed by around 35-40 vessels off Mallorca (Balearic Islands, GFCM GSA5). A fraction of the small-scale fleet (~70 boats) also directs to this species during the second part of the year, using both trammel nets and gillnets. During the last decade, the annual landings of this species have oscillated between 73-117 and 16-29 tons in the trawl and small-scale fishery, respectively.

Limit and target management reference points or levels

Table of limit and target management reference points or levels **proposed by EWG 11-20**

E_{lim} (age range)=	
$F_{0.1}$ (1-5)=	0.26
F_{max} =	
F_{msy} (1-5)=	0.26
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and target management reference points or levels **agreed by fisheries managers**

E_{lim} (age range)=	
$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	

F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

5.3 Summary sheet of European hake (*Merluccius merluccius*) in GSA 7

Species common name:	European hake
Species scientific name	*Merluccius merluccius*
Geographical Sub-area(s) GSA(s):	GSA 7

Most recent state of the stock

The assessment of this stock was presented to GFCM meeting held in Crete (Greece) from 24 to 29 October 2011 (see www.gfcm.org for details).

State of the adult abundance and biomass:

No trend was observed for total biomass during the analysed period. A slight decrease of the total biomass was observed in the recent years (2008-2010). The spawning stock biomass shows a slight decrease on the time serie. In the absence of a precautionary reference point the STECF EWG 11-20 is unable to fully evaluate the stock size status.

State of the juvenile (recruits):

Since 1998, 3 recruitments appear to be above average (1998, 2002 and 2007-2008). No trend is observed. Since the last 3 years, the recruitment is decreasing.

State of exploitation:

The STECF EWG 11-20 proposes $F_{0.1}$= 0.24 as F_{MSY} proxy. The current F_{curr} is 1.43. The STECF EWG 11-20 considered that the stock is overexploited and recommends fishing mortality to be reduced to the proposed reference point to achieve long term sustainability. GFCM recommendations were the same as STECF EWG 11-20.

Source of data and methods:

Data coming from DCF (size distribution of catches for French and Spanish trawlers, French gillnetters and Spanish longliners, landings) for the period 1998-2010 were used to run the Extended Survivor Analysis (XSA), method calibrated with MEDITS abundance indices for 1998-2010.

Discards were not included in the catches before 2008 because of very few discards. In 2008, discards were substantial (173 t) and thus they were included in the catches. In 2009, the level of the discards decreased (9 t) and they were included in the catches. In 2010, no data of discards was available but the level of discards was considered to be very low, likely due to the fact that the recruitment in 2009 and 2010 was very low.

The following parameters were used for XSA analyses:

Growth parameters (Mellon et al, 2010) Males : Linf = 72.8 cm ; k = 0.233 ; t0 = No Females : Linf = 100.7 cm ; k = 0.236 ; t0 = No
Length Weight (*): a = 0.0085 ; b = 2.97
M vector (ProdBIOM, 1997) : 0.88(0);0.43(1);0.33(2);0.25(3);0.22(4);0.20(5);0.19(6);0.18(7);0.17(8+)
Maturity (*) : 0(0);0.11(1);0.63(2);0.91(3);0.98(4);0.99(5);1.00(6);1.00(7);1.00(8)

(*) data collected by IFREMER for DCF in GSA 7 (2003-2010) computed with inbio R scripts developed by IEO

Outlook and management advice

STECF EWG 11-20 recommended the relevant fleets' effort to be reduced until fishing mortality is below or at the proposed level F_{MSY}, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects.

Short and medium term scenarios:

Short and medium term predictions of stock biomass and catches will be performed in the STECF EWG 11-20 meeting.

Fisheries

Hake (Merluccius merluccius) is one of the most important demersal target species of the commercial fisheries in the Gulf of Lions (GFCM-GSA07). In this area, hake is exploited by French trawlers, French gillnetters, Spanish trawlers and Spanish long-liners. Around 220 boats are involved in this fishery and, according to official statistics, total annual landings for the period 1998-2010 have oscillated around a mean value of 2250 tons (1980 tons in 2009). The fishing capacity of the GSA 07 has shown in these last 10 years a progressive decrease considering the French trawlers. The number of these trawlers decreased of about 30% during the period.

Most fleets and catches correspond to French trawlers (44 and 72%, respectively). Trawlers catches range between 3 and 92 cm total length (TL), with an average size of 20 cm TL, followed by French gillnetters (~39 and 14% respectively, ranging 13-86 cm TL and average size 39 cm TL), Spanish trawlers (~11 and 8%, respectively, ranging 5-87 cm TL, and average size 25 cm TL), and Spanish long-liners (~6 and 6%, respectively, ranging 23-96 cm TL and average size 54 cm TL). Hake trawlers fishery exploits a highly diversified species assemblage: Striped mullet (*Mullus surmuletus*), Red mullet (*Mullus barbatus*), Angler (*Lophius piscatorius*), Black-bellied angler (*Lophius budegassa*), European conger (*Conger conger*), Poor-cod (*Trisopterus minutus capelanus*), Fourspotted megrim (*Lepidorhombus boscii*), Soles (*Solea spp.*), horned octopus (*Eledone cirrhosa*), squids (Illex coindetii), Gilthead seabream (Sparus aurata), European seabass (Dicentrarchus labrax), Seabreams (Pagellus spp.), Blue whiting (*Micromesistius poutassou*), Tub gurnard (*Chelidonichtys lucerna*).

COUNTRY	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
French trawlers	1688	1525	1347	1835	2168	2024	1023	1002	1014	1282	2071	1642	1527
Spanish trawlers	140	279	166	196	231	206	101	125	116	107	192	258	156
French gillnetters	500	500	500	500	182	248	99	255	299	168	111	286	247
Spanish longliners	101	109	285	163	146	112	78	101	170	143	97	83	53

Total catches (in tons) of *Merluccius merluccius* by gear in GSA07 (1998-2010)

Limit and precautionary management reference points

Table of limit and precautionary management reference points proposed by STECF EWG 11-12

$F_{0.1}$ (0-3)	0.24
F_{max} (0-3)=	
F_{msy} (0-3)=	0.24
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and precautionary management reference points agreed by fisheries managers

$F_{0.1}$ (mean)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

5.4 Summary sheet of red mullet (*Mullus barbatus*) in GSA 7

Species common name:	Red mullet
Species scientific name	*Mullus barbatus*
Geographical Sub-area(s) GSA(s):	GSA 7

Most recent state of the stock

The assessment of this stock was presented to GFCM meeting held in Crete (Greece) from 24 to 29 October 2011 (see www.gfcm.org for details).

State of the adult abundance and biomass:

The total biomass fluctuates with no trend since 2004 but with a large increase in 2009. The SSB shows an increasing trend on the period with a high value in 2008. In the absence of a precautionary reference point the STECF EWG 11-20 is unable to fully evaluate the stock size status.

State of the juvenile (recruits):

Recruitment shows some increase in the most recent years, 2009 and especially 2010.

State of exploitation:

The STECF EWG 11-20 proposes the referent point $F_{0.1}$= 0.51 as a proxy of F_{MSY}, consistent with high long term yield an low risk of fisheries collapses (the same was proposed by GFCM WG). The current fishing mortality F_{curr} = 0.93 is higher than F_{MSY}. Thus, STECF EWG 11-20 considered that the stock is overexploited and recommends fishing mortality to be reduced until fishing mortality is at or below the estimated F_{msy} reference point. GFCM recommendations were the same as STECF EWG 11-20.

Source of data and methods:

Data coming from DCF (size distribution of catches for French and Spanish trawlers, landings) for the period 2004-2010 were used to run the Extended Survivor Analysis (XSA), method calibrated with MEDITS abundance indices for 2004-2010. No discards were included.

The following parameters were used for XSA analyses:

Growth parameters (GSA 9*) Linf = 29 cm ; k = 0.6 ; t0 = -0.1
Length Weight (**) : a = 0.0085 ; b = 2.97
M vector (ProdBiom, 1997) : 1.30 (0); 0.79 (1); 0.62 (2); 0.54 (3); 0.54 (4); 0.54 (5+)
Maturity (*) : 0.30(0);0.57(1);0.80(2);0.92(3);0.97(4);0.99(5+)

(*) Growth parameters used were fast growth parameters estimated for the GSA 9. The growth parameters estimated in GSA 7, with otolith readings showed a slow growth, which was not consistent with the other analysis performed in other GSAs using fast growth parameters. Maturity ogive is the same as the GSA 9

(**) data collected by IFREMER for DCF in GSA 7 (2003-2010) computed with inbio R scripts developed by IEO

Outlook and management advice

EWG 11-20 recommends the relevant fleets effort to be reduced until fishing mortality is below or at the proposed level F_{MSY}, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects. Catches and effort consistent with F_{MSY} should be estimated.

Short and medium term scenarios:

Short and medium term predictions of stock biomass and catches will be conducted during the STECF EWG 11-20 meeting.

Fisheries

In the Gulf of Lions (GSA 7), red mullet (*Mullus barbatus*) is exploited by both French and Spanish trawlers. Around 120 boats are involved in this fishery. According to official statistics, total annual landings for the period 2004-2010 have oscillated around a mean value of 157 tons. Most boats and catches correspond to the French trawling fleet (80% and 85% respectively). In French and Spanish landings, modal length is 14 cm. In GSA 7, the trawl fishery is a multi-specific fishery. In addition to *M. barbatus*, the following species can be considered important by-catches: *Merluccius merluccius, Lophius* spp.*, Pagellus* spp.*, Trachurus* spp.*, Mullus surmuletus, Octopus vulgaris, Eledone* spp.*, Scyliorhinus canicula, Trachinus* spp.*, Triglidae, Scorpaena* spp. Length at first capture is about 7 cm. Catch is mainly composed by individuals of age 0 and 1 while the oldest age class (5+ group) is poorly represented. Catch rates decreased slightly along the analysed period. The number of French boats decreased also of about 30 % on the period.

Total catches (in tons) of *Mullus barbatus* by gear in GSA 7 (2004-2010)

COUNTRY	2004	2005	2006	2007	2008	2009	2010
FRA	151	148	183	172	111	120	219
ESP	26	28	33	37	21	26	25

Limit and precautionary management reference points

Table of limit and precautionary management reference points proposed by STECF EWG 11-20

$F_{0.1}$ (0-3)	0.51 (average for age classes 0-3)
F_{max} (age range)=	
F_{msy} (0-3)=	0.51 (average for age classes 0-3)
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and precautionary management reference points agreed by fisheries managers

$F_{0.1}$ (mean)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

5.5 Summary sheet of European hake (*Merluccius merluccius*) in GSA 10

Species common name:	European hake
Species scientific name:	*Merluccius merluccius* (L., 1758)
Geographical Sub-area(s) GSA(s):	GSA 10

Most recent state of the stock

<u>State of the adult abundance and biomass:</u>

Survey indices indicate a variable pattern of abundance (n/h) and biomass (kg/h) without a clear trend. However, recent values are among the higher observed since 1994. The Aladym model showed instead that the SSB was decreasing. No precautionary biomass reference points have been proposed for this stock. As a result, EWG 11-20 is unable to fully evaluate the status of the stock with respect to the biomass.

<u>State of the juvenile (recruits):</u>

Recent recruitment since 2005 appears to be above average, as derived directly from the trawl survey estimates considering as recruits the age 0 group (Fig. 7.3.6.1.2.1) and from the SURBA model analysis.

<u>State of exploitation:</u>

EWG 11-20 proposes $F \leq 0.2$ as limit management reference point (basis $F_{0.1}$ as a proxy of F_{MSY}) consistent with high long term yields. Given the results of the present analysis, the stock appeared to be subject to overfishing in 2006-2010, as the estimates of fishing mortality was 0.63 in 2010. Regardless of the growth pattern a considerable reduction is necessary to approach the F_{MSY} reference point (Factor; ~65-70% of the current F value, depending on the year). However, considering the high productivity in terms of incoming year classes, this stock has the potential to recover fast if F is reduced towards F_{MSY}.

<u>Source of data and methods:</u>

The data used in the analyses were from trawl surveys (time series of MEDITS and GRUND surveys from 1994 to 2010 and from 1994 to 2006 respectively) and from fisheries up to 2010.

The analyses on the population were conducted using SURBA, ALADYM and VIT models in a complementary way. Two growth scenarios were tested: <u>Set 1) ‘slow’ growth:</u> L_∞=97.9 cm, K=0.135, t_0= -0.4; length-weight relationship: a=0.00355, b=3.22 for sex combined. <u>Set 2) ‘fast’ growth:</u> L_∞=104 cm, K=0.2, t_0= -0.01; length-weight relationship: a=0.00355, b=3.22 for sex combined. Natural mortality vector for the two scenarios were obtained applying the Prodbiom method. Size at first maturity was varying around 32 cm (maturity range 2 cm).

Outlook and management advice

EWG 11-20 recommends the relevant fleet's effort to be reduced until fishing mortality is below or at F_{MSY} in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects.

Fisheries

M. merluccius is with red mullet and deep-water pink shrimp a key species of fishing assemblages in the central-southern Tyrrhenian Sea. Fishing grounds are located on the soft bottoms of continental shelves and the upper part of continental slope along the coasts of the whole GSA. Catches from trawlers are from a depth range between 50-60 and 500 m and hake occurs with other important commercial species as *Illex coindetii*, *M. barbatus*, *P. longirostris*, *Eledone* spp., *Todaropsis eblanae*, *Lophius* spp., *Pagellus* spp., *P. blennoides*, *N. norvegicus*. Since 2004, landings of hake increased from 1,338 t to 1,536 t in 2006, then decreased to about 1,091 t in 2009 and increased to about 1300 t in 2010. Most part of the landings of hake is from trawlers and nets (GNS and GTR), but the catches of the demersal long-line fishery are also important.

Annual landings (tons) by major gear type, 2004-2010.

Species	GEAR	FISHERY	2004	2005	2006	2007	2008	2009	2010
HKE			198	186	8				
HKE	GND	SPF	7		12	11	8	9	
HKE	GNS	DEMF	177	294	323	213	311	282	431
HKE	GNS	SLPF				7		2	
HKE	GTR	DEMSP	202	124	152	157	68	107	202
HKE	LLD	LPF					2	3	
HKE	LLS	DEMF	266	269	288	240	232	247	184
HKE	OTB	DWSP			14	4	3	8	
HKE	OTB	DEMSP	186		97	173	351	277	
HKE	OTB	MDDWSP	300	612	649	464	147	156	
HKE	OTB								475
HKE	PS	SPF	1		2				
HKE	SB-SV	DEMSP	1						

Limit and precautionary management reference points

Table of limit and precautionary management reference points **proposed by** EWG 11-20

$F_{0.1}$ (all classes)	≤0.2
F_{max} (age range)	
F_{msy} (all classes) =	≤0.2
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and precautionary management reference points **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of hake in GSA 10 can be found in section 6.7 of this report.

The short and medium terms forecasts are in the section 7.17 of this report.

5.6 Summary sheet of red mullet (*Mullus barbatus*) in GSA 10

Species common name:	Red mullet
Species scientific name:	*Mullus barbatus*
Geographical Sub-area(s) GSA(s):	GSA 10

Most recent state of the stock

State of the adult abundance and biomass:

In the absence of proposed and agreed precautionary management reference points EWG 11-20 is unable to fully evaluate the state of the SSB. However, survey indices indicate a variable pattern of biomass with the recent values amongst the lowest observed, except for 2007 and a decrease pattern of biomass indices.

State of the juvenile (recruits):

In 2007 and 2009 the MEDITS surveys indicated high indices of recruit abundance, while in 2010 the index was among the lower observed in the time series.

State of exploitation:

EWG 11-20 proposes $F_{MSY} \leq 0.4$ as limit management reference point (basis $F_{0.1}$ as a proxy of F_{MSY}) consistent with high long term yields. Thus, given the results of the present analysis (F 2006=1.3, F 2007=0.76, F 2008=1.38; F 2009=0.98, F 2010=1.01), the stock appeared to have been subject to overfishing during 2006-2010. A reduction of F of about 62% would be thus necessary in order to avoid future loss in stock productivity and landings.

Source of data and methods:

The data used in the analyses were from trawl surveys (time series of MEDITS and GRUND surveys from 1994 to 2010 and from 1994 to 2006 respectively) and from fisheries. The stock is assessed by a VPA (VIT) using the pseudocohort approach for each year (2006, 2007, 2008, 2009, 2010). A sex combined analysis was carried out. The growth parameters used are L_{∞}=30 cm k=0.4 t_0= -0.4. The length-weight relationship parameters were: a=0.0103; b=3.0246. A constant natural mortality M (Alagaraja) = 0.61 was adopted, because this value was close to 0.70, an estimate reported for a very slightly exploited area in the Castellammare Gulf (northern Sicily coasts) within the GSA. The setting of the proportion of mature females was 0.16 at age 0, 0.92 at age 1 and 1 at age 2. Management reference points were estimated by an YPR analysis.

Outlook and management advice

EWG 11-20 recommends the relevant fleet's effort to be reduced until fishing mortality is below or at F_{MSY} in order to avoid future loss in stock productivity and landings. This should be achieved by effort reductions of the relevant fleets by means of a multi-annual management plan taking into account mixed-fisheries effects. Catch forecasts consistent with the effort reductions shall be estimated.

Fisheries

Red mullet is an important species in the area, targeted by trawlers and small scale fisheries using mainly gillnet and trammel nets. Fishing grounds are located along the coasts of the whole GSA within the continental shelves. Available landing data collected under the DCF framework range from 513 tons of 2004 to 176 tons in 2010, the latter being the lowest value registered. Most part of the landings of red mullet were from trawlers up to 2006, while since 2007 the level of catches of trawlers is similar to that of the other métier grouped together, to which the maximum contribution is given by gillnet (GNS) and trammel net (GTR). Since 2008 the catches of both métier are decreasing.

Annual landings by major fishing techniques in tons for red mullet in the GSA 10 (2004-2010).

Area	Species	Gear	Fishery	2004	2005	2006	2007	2008	2009	2010
10	MUT			10	39	1				
10	MUT	SPF			0					
10	MUT	GNS	DEMF	16	25	35	24	7	7	15
10	MUT	GTR	DEMSP	96	102	68	212	133	98	26
10	MUT	LLS	DEMF	1						
10	MUT	OTB								
10	MUT	OTB	DWSP			1	0	0	0	
10	MUT	OTB	DEMSP	184		19	43	146	122	92
10	MUT	OTB	MDDWSP	217	255	269	222	36	51	43
10	MUT	SB-SV	DEMSP	2						

Limit and precautionary management reference points

Table of limit and precautionary management reference points **proposed by EWG 11-20**

$F_{0.1}$ (all classes) =	≤0.41
F_{max} (age range) =	
F_{msy} (all classes) =	≤0.41
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and precautionary management reference points **agreed by fisheries managers**

F0.1 (age range)=	
Fmax (age range)=	
Fmsy (age range)=	
Fpa (Flim) (age range)=	
Bmsy (spawning stock)=	
Bpa (Blim, spawning stock)=	

Comments on the assessment

The detailed assessment of red mullet in GSA 10 can be found in section 6.2 of this report.

The short terms forecasts are reported in the section 7.18 of this report.

5.7 Summary sheet of pink shrimp (*Parapenaeus longirostris*) in GSA 10

Species common name:	Deepwater pink shrimp
Species scientific name:	*Parapenaeus longirostris*
Geographical Sub-area(s) GSA(s):	GSA 10

Most recent state of the stock

State of the adult abundance and biomass:

In the absence of proposed and agreed precautionary management references, EWG 11-20 is unable to fully evaluate the status of SSB. Survey indices indicate a variable pattern of abundance (n/h) and biomass (kg/h) without a clear trend. MEDITS indices indicate a sharp decrease from 2006 to 2007 and then a slight increase. GRUND data showed a decrease of abundance and biomass from 2005 to 2006 after an increasing phase.

State of the juveniles (recruits):

Recruitment estimates from GRUND surveys showed a decrease in abundance from 2005 to 2006 after an increase from 2002 to 2005, whilst recruitment indices from MEDITS were among the lowest in the time series.

State of exploitation:

EWG 11-20 proposes $F \leq 0.71$ as limit management reference point of exploitation consistent with high long term yield (basis $F_{0.1}$ as F_{MSY} proxy). Given the results of the present analysis (F current of 2010 about 1.1), the stock is considered subject to overfishing during the period 2006-2010. EWG 11-20 recommends the relevant fleets' effort to be reduced to reach the proposed level F_{MSY}, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan. However the dynamics of this species seems also influenced by environmental changes.

Source of data and methods:

The analyses were conducted using VIT and YIELD software. The following growth parameters were used to split the LFD for the VIT age-class analyses; females: CL_∞ = 4.6 cm, K= 0.575, t_0= -0.2; males: CL_∞ = 4 cm, K= 0.68, t_0= -0.25. Since YIELD software uses only specimens total lengths data for the analyses, growth parameters and length-weight relationship coefficients were converted to the following equation: TL_∞ = 20.77 cm, K= 0.575, t_0= -0.23, a= 0.0178, b= 2.5423. Constant natural mortality M (mean natural mortality over all the age classes) = 0.9 and a constant recruitment of 360 million individuals were assumed (average recruitment estimated by VIT during 2006-2010) to parameterize YIELD software. Management reference points were estimated by an YPR analysis.

Outlook and management advice

EWG 11-20 recommends the relevant fleets' effort to be reduced to reach the proposed level $F_{0.1}$, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed fisheries effects.

Fisheries

The pink shrimp is only targeted by trawlers and fishing grounds are located on the soft bottoms of continental shelves and the continental slope along the coasts of the whole GSA. The pink shrimp occurs mainly with *M. merluccius*, *M. barbatus*, *Eledone cirrhosa*, *Illex coindetii* and *Todaropsis eblanae, N. norvegicus*, *P. blennoides*, depending on depth and area.

The catches of the species raised from 2004 to 2006 when 1089 tons were recorded and then declined to 370 tons in 2010 a value lower than in 2004 (552 tons).

Annual landings (t) by gear type, 2004-2010.

Species	Area	Country	Gear	Fishery	2004	2005	2006	2007	2008	2009	2010
DPS	10	ITA			2	1					
			GNS	DEMF	3	6					
			GTR	DEMSP	3						
			LLS	DEMF		26					
			OTB	DEMSP			17	2	5	14	242
			OTB	DWSP	151		391	180	226	197	3
			OTB	MDDWSP	393	743	679	353	169	168	125
			Total		552	776	1088	534	400	379	370

Limit and precautionary management reference points

Table of limit and precautionary management reference points **proposed by EWG 11-20**

$F_{0.1}$ (all classes)=	$\leq$0.71
F_{max} (age range)=	
F_{msy} (all classes)=	$\leq$0.71
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and precautionary management reference points **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

The detailed assessment of pink shrimp GSA 10 can be found in section 6.2 of this report.

The short and medium terms forecasts are reported in the section 7.18 of this report.

5.8 Summary sheet of European hake (*Merluccius merluccius*) in GSA 11

Species common name:	European hake
Species scientific name:	*Merluccius merluccius* (L., 1758)
Geographical Sub-area(s) GSA(s):	GSA 11

Most recent state of the stock

State of the adult abundance and biomass:

STECF EWG 11-20 could not estimate the absolute levels of stock abundance. MEDITS abundance (n/km²) and biomass (kg/km²) indices do not indicate a significant trend. The stock SSB calculated using SURBA periodically oscillated on the period and has decreased in the last 5 years showed to the low values in 2009 and a slight increase in 2010.

State of the juvenile (recruits):

STECF EWG 11-20 could not estimate the absolute levels of recruitment. However, relative indices estimated by SURBA indicated very high fluctuations of recruitment in the period 1994-2010.

State of exploitation:

The reference points ($F_{0.1}$ and F_{max}) estimated for this species using the Yield software were 0.23 and 0.38, respectively. SGMED notes that the current mean F ($F_{0\text{-}2}$=0.56) is far in excess of the proposed target reference point $F_{0.1}$ (basis $F_{0.1}$ as F_{MSY} proxy) and also exceeds F_{max}.

Assuming similar selection patters of the survey and the commercial fishery, EWG 11-20 concludes that the stock is overfished.

Source of data and methods:

The SURBA software program was used to analyse the MEDITS time series (1994-2010) and to estimate relative SSB and F. Data coming from DCF (age distribution of catch for OTB) for the period 2006, 2009 and 2010 were used to run the VIT.

The following parameters were used both for SURBA and VIT analyses:

VBGF	L_∞=100 cm, K=0.24, t0= -0.01
L*W relationship	a = 0.004, b= 3.156
M vector	Age_0=1.11, Age_1=0.51, Age_2=0.39, Age_3=0.33, Age_4=0.31, Age_{5+}=0.29 (ProdBiom)
Catchability (q)	q_0 = 0.7, $q_{1\text{-}3}$ = 1.0, q_4=0.75, q_5=0.6
Length at maturity (L50)	36 cm (sex combined)

Outlook and management advice

EWG recommends the relevant fleets' effort to be reduced until fishing mortality is below or at the proposed level F_{MSY}, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan. Catches consistent with the effort reductions should be estimated.

Fisheries

Hake is exploited in all trawlable areas around Sardinia and is one of the most important target species showing the highest landings.

According to the scientist's knowledge of the GSA 11 landings of hake comes almost entirely from bottom trawl vessels whereas catches from trammel nets or longlines are negligible. Small hakes are commonly caught from shallow waters about 50 m to 300 m depth, whereas adults reach the maximum depths exploited (800 m). Both small and adults catches coming from a mixed fishery, then in the GSA there is not a specific Hake fishery. The most important by catch species are horned octopus (*Eledone cirrhosa*), squids (*Illex coindetii*), poor cod (*Trisopterus minutus capelanus*) at depths less than 350 m and (*Chlorophtalmus agassizii*), greater forkbeard (*Phycis blennoides*) and deep-water pink shrimp at greater depth (*Parapenaeus longirostris*).

At the end of 2006 the trawl fleet of GSA11 accounted for 157 vessels (11.7% of the overall Sardinian fishery fleet). The main trawl fleets of GSA11 are present in the following harbors: Cagliari, Alghero, Porto Torres, La Caletta, Sant'antioco, Oristano, Alghero and Arbatax. The fishing capacity of the GSA trawl fleet has shown in these last 15 years remarkable changes. From 1994 to 2004 a general increase in the number of vessels and by the replacement of the old, low tonnage wooden boats by larger steel boats.

Using data available to EGW-11-20, the trends in fishing show a major drop of total fishing effort in 2008, when both the trawlers and the small scale fishery effort decrease (of 25 and 31 % respectively). In the last three years the effort was almost stable.

The total landings of hake of GSA 11 in the last 6 years decreased from 866 t (2005) to 268 t in 2009 an slightly increase in 2010 (324 t). The major drop occur in 2007, and progress in the following 3 years.

Trend in fishing effort (kW*days,) by major gear types, 2004-2010.

Tab. 5.8.1 Trend in fishing effort (kW*days) for Italy in GSA 11 for the major gear types in 2004-2010.

GEAR	2004	2005	2006	2007	2008	2009	2010
FPO	42030	77070	960931	1497019	921315	1039432	999287
FYK				1140			
GNS	1157504	1065868	204874	777750	453491	979982	558828
GTR	6584427	7186648	7227466	4932023	3719222	4103101	4333105
LHP							
LLD	118760	280487	468325	1311593	927405	514982	647982
LLS	1048740	941723	1329827	1135473	649943	672281	530352
LTL			6689	1744	589	566	
none	18500	786	65516	143525	62994	44038	9193
OTB	7706431	7324728	5752588	5865498	4430174	4375729	4041363
PS	27293						
total	16703685	16877310	16016216	15665765	11165133	11730111	11120110

Landings (t) by year and major gear types, 2005-2010 as reported through DCR

FT_LVL4	2005	2006	2007	2008	2009	2010
GTR	101	206		29		58
LLS					7	
OTB	765	594	442	279	261	267
total landings (all gears)	866	800	442	307	268	324

Limit and target management reference points or levels

Table of limit and target management reference points or levels **proposed by EWG**

$F_{0.1}$=	0.27
F_{max}=	
F_{msy} (age range)=	0.27
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and target management reference points or levels **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

GRUND data should be standardized and used in the assessment. Updated and quality checked landings data are essential to apply other assessment approach such as LCA.

Data Quality check

MEDITS survey data were available from 1994 to 2010, while 2011 is missing as for the other Italian GSAs.

STECF noted that landing and discard seems to be misreported in some years. In particular landings at length for GTR are not reported in 2007 and 2009, while for LLS are only reported in 2009. Even if the contribution to total landings of these fisheries (GTR and LLS) is not high in the GSA11, it is not clear to EGW 11-20 if they are or not belonging to a real fishery for hake.

Furthermore, like in other italian GSAs, discards were only reported for OTB in 2006, 2009 and 2010, when were mandatory for DCR.

For GTR discards are reported in 2005 and 2010, but data seems to be not reliable neither because the length distribution (discards' lengths range from 27 to 44 cm), nor because is the only SA where have been reported for those gear.

Since the significance of the discards component for the assessment of hake and because of the incosistences noted above, EWG 11-20 decide to use only 3 years for the analysis (i.e. when discard were reported for OTB).

5.9 Summary sheet of red mullet (*Mullus barbatus*) in GSA 11

Species common name:	Red mullet
Species scientific name:	*Mullus barbatus*
Geographical Sub-area(s) GSA(s):	GSA 11

Most recent state of the stock

State of the adult abundance and biomass:

STECF EWG 11-20 could not estimate the absolute levels of stock abundance. MEDITS abundance (n/km²) and biomass (kg/km²) indices do not indicate a significant trend. The stock SSB calculated using SURBA periodically oscillated on the period and has decreased in the last 5 years showed to the low in 2009.

State of the juvenile (recruits):

STECF EWG 11-20 could not estimate the absolute levels of recruitment. However, relative indices estimated by SURBA indicated high fluctuations of recruitment.

State of exploitation:

The reference points ($F_{0.1}$ and F_{max}) were 0.47 and 0.68, respectively. SGMED notes that current mean F estimated either by SURBA and LCA (F_{1-3}=1.9 and 1.5) are far in excess of the proposed target reference point $F_{0.1}$ (basis $F_{0.1}$ as F_{MSY} proxy) and also exceeds F_{max}, suggesting that the stock in the GSA 11 is overexploited.

A reduction of F between 30-50% would be thus necessary in order to avoid future loss in stock productivity and landings.

Source of data and methods:

The present assessment was derived by both indirect and direct data. By using VIT and SURBA the status stock was assessed considering the same set of parameters reported below. Vectors of natural mortality calculated from ProdBiom was used.

VBGF	L_∞=29.1 cm, K=0.41, t_0= -0.39
M vector	Age_0=1.30, Age_1=0.41, Age_2=0.27, Age_3=0.24
Catchability (q)	q_{1-3} = 1
Length at maturity (L50)	13 cm (sex combined)
Age at maturity	1
Age at first capture	0.7

Outlook and management advice

The EWG 11-20 recommends the relevant fleets' effort to be reduced until fishing mortality is below or at the proposed level $F_{0.1}$, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan. Catches consistent with the effort reductions should be estimated. The enforcement of the minimum landing size (fixed at 11 cm TL since 1995) and the recent (June 2010) enforcement of EC Council Regulation No 1967/2006 that changed the gear selectivity might have positive impact on the productivity of the stock in the near future. Finally a big effort in achieving realistic indirect fishing effort information as well as the necessary control policy to avoid misapplication of EC regulation should be included in the management plan.

Fisheries

Red mullet is exploited in all trawlable areas around Sardinia and is one of the most important target species showing the highest landings on shelf bottoms, together with the cephalopod *Octopus vulgaris*.

According to the scientist's knowledge of the GSA11 landings of red mullet comes both from bottom trawl vessels and small artisanal fishery.

Commonly small red mullets are caught at around 50 m of depth where show high dense patches, whereas adults are caught at greater depths where are less concentrate. Both juvenile and adults catches coming from a mixed fishery, then in the GSA there is not a specific fishery target on red mullet.

At the end of 2006 the trawl fleet of GSA11 accounted for 157 vessels (11.7% of the overall Sardinian fishery fleet). The main trawl fleets of GSA11 are present in the following harbours: Cagliari, Alghero, Porto Torres, La Caletta, Sant'antioco, Oristano, Alghero and Arbatax.

The fishing capacity of the GSA trawl fleet has shown in these last 15 years remarkable changes. From 1994 to 2004 a general increase in the number of vessels and by the replacement of the old, low tonnage wooden boats by larger steel boats. In the latest years the effort shows a peak in 2005, then continuously decrease and drop in 2008 and 2009.

Since 2004 the annual landings varied between 222 and 346 t, with a consistent drop (-22% of the 6 years mean) in the last year (2009). The landings were mainly from demersal otter trawls (catches from other gears are less than 5% of the total).

Precautionary and target management reference points or levels

Table of limit and target management reference points or levels **proposed by SGMED**

$F_{0.1}$ (from VIT, average for all age classes)	0.48
F_{max} (age range)	
F_{msy} (average for all age classes)	0.48
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of **agreed** precautionary and target management reference points or levels

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

Because the biology of the species, direct information which refer to autumn period (GRUND survey) should be standardized and used in the assessment to fully evaluate the state and the contribution of the recruits fraction to the stock. Equally updated and quality checked landings data (discard included) are essential to future update and confirm the assessment proposed.

5.10 Summary sheet of Sardine (*Sardina pilchardus*) in GSA 17

Species common name:	Sardine
Species scientific name	*Sardina pilchardus*
Geographical Sub-area(s) GSA(s):	GSA 17

The present assessment has been performed by the FAO-ADRIAMED Working Group and presented at the GFCM working group for small pelagic in Chiania (2011) (see www.gfcm.org for details).

Most recent state of the stock

State of the adult abundance and biomass:

According to the VPA and preliminary ICA analyses the SSB shows a constant recovery since 1999. The average stock biomass in the last 3 years is about 184,000 t. In the GFCM stock assessment form the abundance of the stock is considered “low”. The acoustic survey in 2010 estimated a biomass at sea for the entire GSA17 of about 273,200 t.

State of the juvenile (recruits):

According to VPA and preliminary ICA analyses the recruitment of sardine in GSA 17 is fluctuating around an average value of 1 billion since 2000, and reached in 2010 a value of approximately 13 billions.

State of exploitation:

The fishing mortality shows a peak for the oldest ages in 2009 in both VPA and ICA: a possible explanation is the increase in the catch of all the ages respect to age 1. Despite this value, since 2004 the F remains below 0.5, increasing to 0.6 only in 2010. The recent exploitation rate F/Z (E) is slightly under the Patterson’s threshold 0.4 and used as E_{MSY} proxy. Besides that, the ratio between total catch and stock biomass remain stable at low level (0.2). Therefore, the stock is considered sustainably exploited.

Source of data and methods:

Comparing landing data used (data from EU member states) with available DCF data have shown only small deviations.

The data used for the present assessment derive from the catch recorded for the fleets of Italy, Croatia and Slovenia, from 1975 to 2010. The biological data of the species (available since 1975 for the western and from the 2001 for the eastern side) were used to obtain the age distribution in the catches.

Echo-survey abundance index was used to tune the models. The echo-surveys were carried out for both the western and eastern sides from 2004 onwards. Western echo-survey abundances were split into age classes by the means of length frequency distribution coming from the western echo-survey and age-length key coming from the Italian commercial fleet. On the other hand, eastern echo-survey abundance was distributed into age classes by the means of length frequencies and age-length key coming from the Croatian commercial catches.

Calendar year was used, by fixing the birthday date on the 1st of January, according to the biology of this species in the Adriatic Sea.

The growth parameters required by this method were derived from Sinovcic (1986):

Linf	20.5
k	0.46
t_0	-0.5

The natural mortality rate M was taken as variable over age and was calculated using the Gislason's equation:

Age 0	2.51
Age 1	1.10
Age 2	0.76
Age 3	0.62
Age 4	0.56
Age 5	0.52
Age 6+	0.50

Shrinkage for F was applied in the VPA. The age class 0 was not included into the analysis since the value of M = 2.51 obtained for this age class would have implied too high and thus not conservative estimates of abundance at sea; also, the age class 0 is not substantial in the total catch at age.

Outlook and management advice

Considering the strong decrease of the stock in the past and the large fluctuations that this stock can displays, STECF EWG 11-20 recommend not to increase the fishing effort and to maintain the exploitation rate below the threshold of 0.4.

The stock assessed shows a strong dependence with recruitment, due to the short life cycle of these species. Therefore, the short-term projections will largely depend on the assumptions taken in terms of the next years' recruitment.

Fisheries

Sardines are fished by purse seiners, attracting fish by light (mainly in Croatia), and pelagic trawlers belonging mainly to Italy and Slovenia. The fishery takes place all year round: a closure period is observed from the Italian pelagic trawlers on August, while from 15th December to 15th January in Croatia.

Exploitation is based on all the age classes from 0 to 6+.

The Croatian catches of sardine represent the great part of the total catches, while the Italian small pelagic fishery concentrate mainly on anchovy (though high amounts were caught by the Italian fleet in the past).

The Italian fleet is composed of about 65 pairs of mid-water trawlers and about 45 purse seiners (with quite different tonnage), with the former being predominant on the latter ones.

In Croatia, small pelagic (mainly sardine) are fished by purse seiners. On the other hand, in Slovenia, mid-water trawlers gradually caused the disappearance of purse seiners since 1991.

Limit and target management reference points or levels

No reference points concerning biomass can be suggested at this point. F_{max} and $F_{0.1}$ are overestimated so precautionary the F_{MSY} is suggestd to be set as the fishing mortality that assures exploitation rate below the empirical level for stock decline (E<0.4, Patterson 1992) for small pelagic.

Table of limit and target management reference points or levels **proposed by SGMED**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
E_{msy} (F/Z, age range 1-3)	0.4
B_{msy} (spawning stock)=	
B_{lim} (spawning stock)=	

Table of limit and target management reference points or levels **agreed by fisheries managers**

$F_{0.1}$ (age range)= ages 1-3	
F_{max} (age range)= ages 1-3	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

It should be noted that Adriatic small pelagic fishery is multispecies and effort on sardine stock cannot be separated from effort on anchovy stock. Hence, management decisions have to be taken considering both species.

It has been recognised that spatial distribution of shared stock of sardine is not limited to GSA17 area only, but it is extended in GSA18 area also. Therefore, it is suggested that future assessments take into account combined data from these two GSAs. Moreover, an important nursery area of this stock is located in Gulf of Manfredonia (GSA18) where the sardine stock is exploited by fry fishery.

STECF EWG 11-20 reviewed and accepted this assessment, and produced short and medium term predictions of stock biomass and catches (section 7.23).

5.11 Summary sheet of European hake (*Merluccius merluccius*) in GSA 18

Species common name:	European hake
Species scientific name:	*Merluccius merluccius* (L., 1758)
Geographical Sub-area(s) GSA(s):	GSA 18

This assessment was performed within the Adriamed project. It was presented and endorsed at the Working Group od Demersal of GFCM of 2011 in Chania (Greece) (see www.gfcm.org for details).

Most recent state of the stock

State of the adult abundance and biomass:

Survey indices indicate a variable pattern of abundance (n/h) and biomass (kg/h) without a temporal trend. However, recent values are higher or similar to those observed since 1996.

Results from ALADYM model showed that current levels of SSB are around 5-6% of the value estimated at F=0. No precautionary biomass reference points have been proposed for this stock. As a result, WG Demersals of GFCM and EWG 12-01 is unable to fully evaluate the status of the stock with respect to spawning biomass.

State of the juvenile (recruits):

MEDITS data showed a sharp increase of recruitment in 2005 and thereafter a level similar or higher than in the past years. In 2008 a new though lower peak was observed. No trends were identified.

State of exploitation:

WG Demersals of GFCM and STECF EWG MED proposes $F \leq 0.21$ as management reference point consistent with high long term yields (basis $F_{0.1}$ as F_{MSY} proxy). Given the results of the present analysis, the stock appeared to be subject to overfishing in 2007-2010. Total and fishing mortality obtained from SURBA showed a decreasing trend to 2004 and than an increasing in 2005 and 2006, thereafter the level was similar to the beginning of the time series and in the last year was higher.

In the fast growth scenario, the Y/R analysis from VIT indicates a current level (year 2010) of fishing mortality of 0.86 for the whole GSA that is comparable with value of the past years on the western side.

Regardless of the growth pattern a considerable reduction is necessary to approach the F_{MSY} reference point (76% of the current F). Simulations below show that this stock has the potential to recover rather quickly if

F is reduced towards F_{MSY}.

Source of data and methods:

The data used in the analyses were from trawl surveys (MEDITS 1994-2010) and from commercial fisheries (2007-2010) on the whole GSA18 for 2010 and on the western side for 2007-2009. Length structure of landings and production by fishing segment for west side were from DCF, while for the east side were collected within a pilot study in the framework of Adriamed project. The assumption that length-frequency distribution (LFD) of Albanian commercial catch was similar to the Italian LFD has been made, due to the unavailability of suitable LFD data; therefore, the LFD of Italian trawlers was raised to the Albanian production of trawlers. Discards were not considered in the analysis.

Two growth scenarios were tested: Set 1) 'slow' growth: L_∞=95 cm, K=0.14, t_0= -0.4; for sex combined. Set 2) 'fast' growth: L_∞=104 cm, K=0.2, t_0= -0.01; length-weight relationship for both scenarios: a=0.00435, b=3.155 for sex combined. LFDs were sliced using the above parameters.

Natural mortality vector for the two scenarios were obtained applying the Prodbiom method. Inputs to SURBA (also in part to VIT) are below reported.

Age	0	1	2	3	4	5+
M (slow)	0.76	0.42	0.3	0.25	0.25	0.25
q (slow)	0.9	1	1	1	0.75	0.75
Proportion mature (slow)	0.0004	0.006	0.43	0.946	1	1
Weight (kg) (slow)	0.01	0.04	0.15	0.35	0.66	1.77
Age	0	1	2	3	4+	
M (fast)	1.16	0.53	0.4	0.35	0.32	
q (fast)	0.9	1	1	0.75	0.75	
Proportion mature (fast)	0.008	0.248	0.887	1	1	
Weight (kg) (fast)	0.01	0.14	0.53	1.15	2.35	

The analyses on the population were conducted using the models: SURBA, VIT, ALADYM and the FLR R routine for the medium term forecast (SGMED, 2010). In addition to the Y/R analysis a transition analysis was performed using VIT, to evaluate the objectives of reaching $F_{0.1}$ and F_{max} through a multiannual reduction of F. Eight scenarios ($F_{0.1}$ and F_{max} in 2015 and 2020 for slow and fast growth scenarios) have been explored. The scenarios were projected until 2030. The model was applied accounting for technical fleet interactions.

In ALADYM harvesting strategies were used to forecast the effects on the population metrics (accounting for cohort structure) and simulated catches. ALADYM was applied using hindcasting and forecasting approaches. Size at first maturity was around 33 cm (maturity range about 4 cm). Z and the recruitment estimated by VIT for 2007-2010 were used as inputs. Recruitment proportion was adjusted to take into account guess potential offsprings distribution among months. To estimate Z and recruitment in 2011 and forward in the status quo scenario a geometric mean among 2007-2010 was calculated.

The fleet selectivity was simulated using an ogive model: Lc=12cm; (SR 1 cm) coupled with a deselection ogive with 50% deselection size at 50 cm and a deselection range of 1 cm, to account for possible reduced availability of older fish. Also the coefficient of monthly activity of the fleet was considered in the simulation, accounting for the current fishing ban in the summer season.

It was assumed that from 2011 the enforcement of 50 mm mesh size was widely applied. Lc=16 cm (SR=1 cm) until the end of simulation. Four scenarios were tested: simulation from 2007 to 2030, in the slow and fast growth scenarios, with increase of Lc from 12 to 16 cm (status quo). Simulation from 2007 to 2030, enforcing mesh size and reducing fishing activity by month (~40% of the current levels) and further reducing F (~15% of the relevant level) on 2014 (slow and fast growth scenario).

The FLR R-routine was used to project two scenarios, starting from a fishing level rescaled to the F current in the fast growth scenario for 2010 (F = 0.86) in order to achieve $F_{0.1}$ (=0.21) until 2015 (annual reduction of 30%, scenario1) and until 2020 (annual reduction of 15%, scenario 2).

Outlook and management advice

Simulations, transition analysis and medium terms forecasts show that after a decrease of the catches in the short terms the total yield or the Y/R trend is increasing and reach levels higher than the values at the beginning of the time series with an improvement of stock productivity. R routine of medium terms forecasts showed a catch reduction till 2015 (annual reduction of F=30%) to achieve $F_{0.1}$ and then an increase, whilst in the scenario 2 the short terms reduction of catches was less evident and a slowly increase of yield was observed.

In Aladym SPR is at very low levels in the status quo scenarios, but shows a remarkable increase (approaching 30%) following the reduction of F. Similar increasing pattern show SSB (~90%) and B/R (~45%) in the medium term forecast and in the transition analysis respectively. An increase in the mean length of catches in 2011 was observed in the simulations and then the value remains quite constant around 25 cm, as consequence of the reduction of fishing mortality and mesh size increase.

The target reference point $F_{0.1}$ can be gradually achieved by multiannual management plans requiring a more sharp reduction in the short term than in the medium term. The objectives of a more sustainable harvest strategy could be achieved with a multiannual plan based on a reduction of fishing mortality through fishing activity limitations and possibly fishing capacity decreasing. It is however necessary to consider that most of the fishing mortality is derived from the Italian bottom trawlers, that represent about 85% of the total F in the GSA, and from the Italian longliners, accounting for about 7-8% (overall 92-93% of F). While Montenegrin trawlers account for about 1% of the F exerted on the GSA and Albanian trawlers for about 6.5%. The production of hake in GSA 18 is split in 14% caught by Italian longlines, 79% by Italian trawlers, about 1% by Montenegrin trawlers and about 6% by Albania trawlers.

Fisheries

Hake is one of the most important species in the GSA 18 representing more than 20% of landings from trawlers. Demersal species catches are landed on the western side (Italian coast) and the eastern side (Albanian and Montenegro coasts), trawling being the most important fishery activity on the whole area with an effort of about 70% of the total effort. In 2010 the landings of hake were about 4020 tons in the west side with the higher production from trawlers (3400 tons) followed by longliners (601 tons) and by the gillnets (19 tons). Along the east side the production from trawlers in 2010 was about 276 tons divided by 36 tons from Montenegro and 240 tons from Albania.

Landings by demersal trawlers dominate the fisheries, however the Mediterranean hake is also caught by off-shore bottom long-lines, but these gears are utilised by a low number of boats (less than 5% of the whole South-western Adriatic fleet). Long-line landings account for about 10-12% of the total hake production.

Fishing grounds are located on the soft bottoms of continental shelves and the upper part of continental slope. Catches from trawlers are from a depth range between 50-60 and 500 m and hake occurs with other important commercial species as *Illex coindetii*, *M. barbatus*, *P. longirostris*, *Eledone spp.*, *Todaropsis eblanae*, *Lophius spp.*, *Pagellus spp.*, *P. blennoides*, *N. norvegicus*.

Annual landings (in tons) by fishing technique, 2004-2010.

Italy				western	Montenegro	Albania	eastern	Total
Year	LLS	NETS	OTB	landings	OTB	OTB	landing	
2004	233	40	2932	3205				3205
2005	452	56	3276	3784				3784
2006	836	56	4613	5505		265	265	5770
2007	620	37	3498	4155		275	275	4430
2008	551	57	3641	4249		249	249	4498
2009	534	28	3536	4098		292	292	4390
2010	601	19	3400	4020	36	240	276	4296

Limit and precautionary management reference points

Table of limit and precautionary management reference points **proposed by EWG 11-20**

$F_{0.1}$ (0-3)	≤0.21
F_{max} (age range)	
F_{msy} (0-3)=	≤0.21
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Table of limit and precautionary management reference points **agreed by fisheries managers**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

Comments on the assessment

5.12 Summary sheet of Sardine (*Sardina pilchardus*) in GSA 22

Species common name:	Sardine
Species scientific name:	*Sardina pilchardus*
Geographical Sub-area(s) GSA(s):	GSA 22

Sardine stock in GSA 22 has been previously assessed for the given historic time series by means of Integrated Catch at Age analysis in the framework of SGMED 02-09. Since there was no update on data available for the specific stock, the suggestion of the STECF EWG 11-20 was to assess the stock by a different analytical methodology and compare results with the assessment done in SGMED 02-09.

Most recent state of the stock

State of the adult abundance and biomass

Given the short length of the time series, STECF EWG 11-20 is unable to precisely estimate the absolute levels of stock abundance and biomass. Survey indices and VPA analyses indicate that average total biomass and SSB presented a decrease in 2003 followed by an increase in 2005 falling afterwards and increasing again in 2008. SSB in 2008 estimated from the XSA model has reached 8,000 t. Limit reference points concerning biomass have not been estimated for this stock, and hence advice relative to these cannot be provided by STECF EWG 11-20.

State of the juvenile (recruits)

XSA model estimates suggest a sharp decrease in 2006 followed by a moderate increase in 2008. Predictions for 2009 also indicate a further increase.

State of exploitation

Based on XSA results, the mean fishing mortality (averaged over ages 1 to 3) showed a clear decreasing trend up to 2004, increasing after 2005, remaining around 0.76 since 2006. The mean F/Z (E) remains above the suggested level of sustainability (E<0.4 as proxy of E_{MSY}) for this stock. Taking the empirical level as a reference point for sustainable exploitation, the stock is considered to be overexploited.

Source of data and methods

This assessment is based on fishery independent surveys information as well as on Extended Survivors Analysis (XSA) analysis model. Specifically, acoustic surveys estimations were used for an age structured abundance index. XSA assessment method is a tuned VPA method that focuses on the relationship between catch per unit effort and population abundance, allowing the use of a more complicated model for the relationship between tuning index and year class strength at the youngest ages. The application of XSA was based on commercial catch data (2000-2008) and as tuning indices were used the biomass estimates from acoustic surveys estimates over the period 2003-2008 with a gap in 2007, as no acoustic survey data were available for this year. Sardine data were comprised of annual sardine landings, annual sardine catch at age data (2000-2008), mean weights at age, maturity at age at age and the results of acoustic surveys.

Different natural mortality were applied per age group but constant for all years based on ProBiom (Abella *et al.*, 1997) as recommended in the report of the SG-ECA/RST/MED 09-01. This method of the estimation of the natural mortality is consistent with the methodology used in GSAs 5, 6 and 17 for small pelagics.

Age 0	Age 1	Age 2	Age 3	Age 4
1.5	0.95	0.69	0.61	0.57

Natural mortality values applied for sardine stock in GSA 22.

The default values of the FLXSA control were used to run the analysis taking into account that the survey is held in the middle of the year. Discards were also included within this assessment representing however only 0.3 % of total landings.

Outlook and management advice

Given the current high exploitation rates, SGMED recommends that fishing mortality should be reduced towards E_{MSY}= 0.4 in order to promote stock recovery and avoid future loss in stock productivity and landings.

Short, medium and long term scenarios

No short term scenario was performed since the last year with data is 2008. This makes the application of a short term scenario meaningless from a management point of view. Two medium term scenarios were performed, one with a change in F up to 2015 and a second one assuming a change in F to MSY situation up to 2020.

Fisheries

In GSA 22 sardine is almost exclusively exploited by the purse seine fleet. Pelagic trawls are banned and benthic trawls are allowed to fish small pelagics in percentages less than 5% of their total catch. Regarding the regulations enforced they concern a closed period from the mid December till the end of February and technical measures such as minimum distance from shore, gear and mesh size, engine, GR. There is a minimum landing size at 11 cm.

Sardine landings showed high variability indicating a decreasing trend since 2005 to 2008, comprising approximately 9700 tons in 2008. Information regarding the age and length distribution of sardine landings prior to 2003 is based on the Hellenic Centre of Marine Research data collection system.

Data of the fishing effort (Days at Sea) and the landings per vessel class indicate that small vessels (12-24 m) (Tables below) are mainly responsible for sardine catches (> 88% of the total catches). The purse seine fishery is considered a mixed fishery, where sardine, anchovy and other species are caught.

Table of sardine landings (in tons) in GSA 22 per vessel size for 2003 to 2006 and 2008 concerning the purse seine fleet in Greek waters derived from data provided to DCR call. Since there was no Data Collection Program in Greece in 2007, data concerning this year are estimations of the Hellenic Centre for Marine Research based on data from other research projects that were held in GSA 22.

Year	PS 12-24 m	PS 24-40 m
2003	7158	634
2004	7267	902
2005	12159	1468
2006	11618	1166
2007	6603	1948
2008	7704	1447

Discards values are less than 1%, reaching approximately 0.3% data for GSA 22.

Table of fishing effort in GSA 22 per vessel size for 2003 to 2008 concerning the purse seine fleet in Greek waters. GRT=Gross tonnage, KW=engine horsepower.

Year	PS 12-24 m	PS 24-40 m	PS 12-24 m	PS 24-40 m	PS 12-24 m	PS 24-40 m
	Days at Sea	Days at Sea	Days at Sea x GRT	Days at Sea x GRT	Days at Sea x KW	Days at Sea x KW
2003	41539	2942	1767398	230726	8709727	679624
2004	39783	3989	1620847	366709	8111571	1029410
2005	42520	5690	1753346	542120	8123673	1532790
2006	37255	5619	1568893	539146	7386042	1606608
2008	35090	4938	1457212	473121	6898061	1335582

Sardine landings for GSA 22 (2000-2008). Since there was no Data Collection Program in Greece in 2007, data concerning this year are estimations of the Hellenic Centre for Marine Research based on data from other research projects that were held in GSA 22.

Limit and target management reference points or levels

No reference points concerning biomass can be suggested at this point. F_{max} and $F_{0.1}$ are overestimated so precautionary the F_{MSY} is suggestd to be set as the fishing mortality that assures exploitation rate below the empirical level for stock decline (E<0.4, Patterson 1992) for small pelagic.

Table of limit and target management reference points or levels **proposed by SGMED**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
E_{msy} (F/Z, age range 1-3)	0.4
B_{msy} (spawning stock)=	
B_{lim} (spawning stock)=	

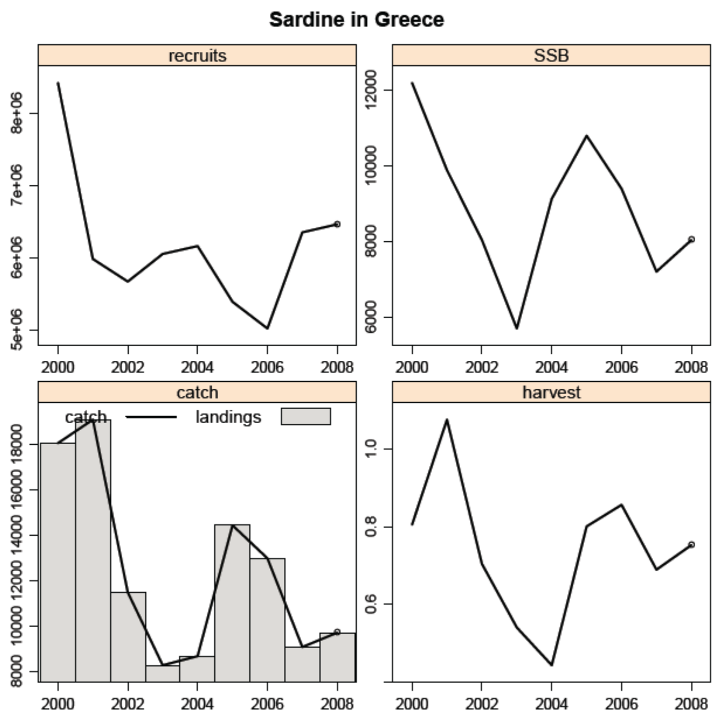
Table of limit and target management reference points or levels **agreed by fisheries managers**

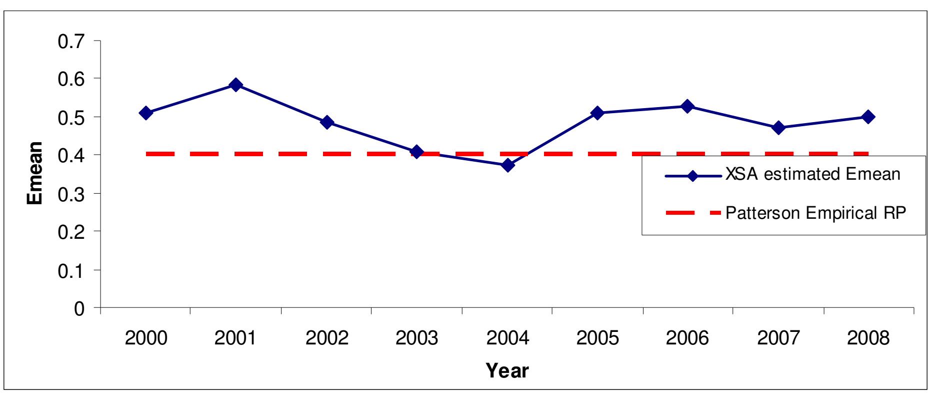
$F_{0.1}$ (age range)= ages 1-3	
F_{max} (age range)= ages 1-3	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

The summary output of the XSA model.

Discards were also included within this assessment representing however only 0.3 % of total landings.

Year	Recruits Age 0 thousands	Total Biomass tonnes	Spawning Biomass tonnes	Landings tonnes	Yield /SSB ratio	Mean F Ages 1-3	Mean E Ages 1-3
2000	8414665	69906	12177	18075	1.484	0.805	0.511
2001	5979688	59135	9877	19115	1.935	1.076	0.584
2002	5666954	47042	8040	11483	1.428	0.704	0.484
2003	6049096	47415	5704	8260	1.448	0.540	0.408
2004	6157934	54447	9122	8660	0.949	0.443	0.374
2005	5387440	77003	10785	14444	1.339	0.801	0.510
2006	5017727	77892	9390	12984	1.383	0.856	0.527
2007	6347948	46845	7204	9064	1.258	0.689	0.472
2008	6459115	51918	8037	9700	1.207	0.752	0.499





Exploitation rate based on F for ages 1 to 3 estimates of XSA results for sardine stock in GSA 22.

5.13 Summary sheet of anchovy (*Engraulis encrasicolus*) in GSA 22

Species common name:	Anchovy
Species scientific name:	*Engraulis encrasicolus*
Geographical Sub-area(s) GSA(s):	GSA 22

Anchovy stock in GSA 22 has been previously assessed for the given historic time series by means of Integrated Catch at Age analysis in the framework of SGMED 09-02. Since there was no update on data available for the specific stock, the suggestion of the STECF EWG 11-20 was to assess the stock by a different analytical methodology and compare results with the assessment done in SGMED 09-02.

Most recent state of the stock

State of the adult abundance and biomass:

Given the short length of the time series, STECF EWG 11-20 is unable to precisely estimate the absolute levels of stock abundance and biomass. Survey indices and VPA analyses indicate that average total biomass and SSB increased since 2006 to 2008. Biomass limit reference points have not been estimated for this stock, and hence advice relative to these cannot be provided by STECF EWG 11-20 in respect to those.

State of the juvenile (recruits):

FLXSA model estimates suggest an increase in recruitment since 2004. The model also predicts a further increase in the population abundance at age 0 for 2009.

State of exploitation:

STECF EWG 11-20 recommends the application of the proposed exploitation rate $E_{MSY} \leq 0.4$ as management target for stocks of anchovy and sardine in the Mediterranean Sea. This value might be revised in the future when more information becomes available.

Based on FLXSA results, the mean E=F/Z (F averaged over ages 1 to 3) has fluctuated around 0.39 and in 2008 has been below the empirical level of sustainability suggested as target exploitation level for this stock. Thus, the stock is considered to be exploited sustainably.

Source of data and methods:

This assessment is based on fishery independent surveys information as well as on Extended Survivors

Analysis (XSA) analysis model. Specifically, acoustic surveys estimations were used for an age structured abundance index. XSA assessment method is a tuned VPA method that focuses on the relationship between the tuning index and population abundance, allowing the use of a more complicated model for the relationship between tuning index and year class strength at the youngest ages. The application of FLXSA was based on commercial catch data (2000-2008) and as tuning indices were used the numbers at age estimates of the population from acoustic surveys over the period 2003-2008 but with a gap for 2007. Anchovy data were comprised of annual anchovy landings, annual anchovy catch at age data (2000-2008), mean weights at age, maturity at age at age and the results of acoustic and DEPM surveys. Different natural mortality were applied per age group but constant for all years based on ProBiom (Abella *et al.*, 1997) as recommended in the report of the SG-ECA/RST/MED 09-01.

Natural mortality values applied for anchovy stock in GSA 22.

Age0	Age1	Age2	Age3	Age4
1.5	1	0.74	0.66	0.62

The default values of the FLXSA control were used to run the analysis taking into account that the survey is held in the middle of the year.

Outlook and management advice

Taking the empirical level as a reference point for sustainable exploitation, the stock is considered to be exploited sustainably. Increased fishing is not expected to result in increased landings in the long term. STECF EWG 11-20 recommends not to increase the effort and to determine consistent catches. Technical interactions regarding the fisheries targeting the sardine stock in GSA 22 need to be taken into account when managing the anchovy fisheries.

<u>Short, medium and long term scenarios:</u>

No short term scenario was performed since the last year with data is 2008. This makes the application of a short term scenario meaningless from a management point of view. Two medium term scenarios were performed, one with a change in F up to 2015 and a second one assuming a change in F to MSY situation up to 2020.

Fisheries

In GSA 22 anchovy is almost exclusively exploited by the purse seine fleet. Pelagic trawls are banned and benthic trawls are allowed to fish small pelagics in percentages less than 5% of their total catch. Regarding the regulations enforced they concern a closed period from the mid December till the end of February and technical measures such as minimum distance from shore, gear and mesh size, engine, GT. There is a minimum landing size at 9 cm.

Anchovy landings showed an increasing trend towards 2008 Anchovy reported landings have showed an increasing trend since 2002, comprising 24,480 tons in 2008. Information regarding the age and length distribution of sardine landings prior to 2003 is based on the Hellenic Centre of Marine Research data collection system.

Data of the fishing effort (Days at Sea) and the landings per vessel class indicate that small vessels (12-24 m) (Tables below) are mainly responsible for anchovy catches (>70% of anchovy catches).

Table of anchovy landings (in t) in GSA 22 per vessel size for 2003 to 2006 and 2008 concerning the purse seine fleet in Greek waters. Since there was no Data Collection Program in Greece in 2007, data concerning this year are estimations of the Hellenic Centre for Marine Research based on data from other research projects that were held in GSA 22.

Year	PS 12-24 m	PS 24-40 m
2003	12507	1495
2004	12222	3877
2005	11073	5274
2006	16121	6190
2007	14875	6625
2008	18188	6293

Discards values are less than 1%, reaching approximately 0.06% data for GSA 22.

Table of fishing effort in GSA 22 per vessel size for 2003 to 2008 concerning the purse seine fleet in Greek waters. GRT=Gross tonnage, KW=engine horsepower.

Year	PS 12-24 m	PS 24-40 m	PS 12-24 m	PS 24-40 m	PS 12-24 m	PS 24-40 m
	Days at Sea	**Days at Sea**	**Days at Sea x GRT**	**Days at Sea x GRT**	**Days at Sea x KW**	**Days at Sea x KW**
2003	41539	2942	1767398	230726	8709727	679624
2004	39783	3989	1620847	366709	8111571	1029410
2005	42520	5690	1753346	542120	8123673	1532790
2006	37255	5619	1568893	539146	7386042	1606608
2008	35090	4938	1457212	473121	6898061	1335582

Limit and target management reference points or levels

No reference points concerning biomass can be suggested at this point due to the small time series of data available. E_{MSY} should be set as the fishing mortality that assures exploitation rate below the empirical level of E<0.4 (Patterson 1992).

Table of limit and target management reference points or levels **proposed by STECF EWG 11-20**

$F_{0.1}$ (age range)=	
F_{max} (age range)=	
F_{msy} (age range)=	
E_{MSY} (F/Z, age range 1-3)	0.4
B_{msy} (spawning stock)=	
B_{lim} (spawning stock)=	

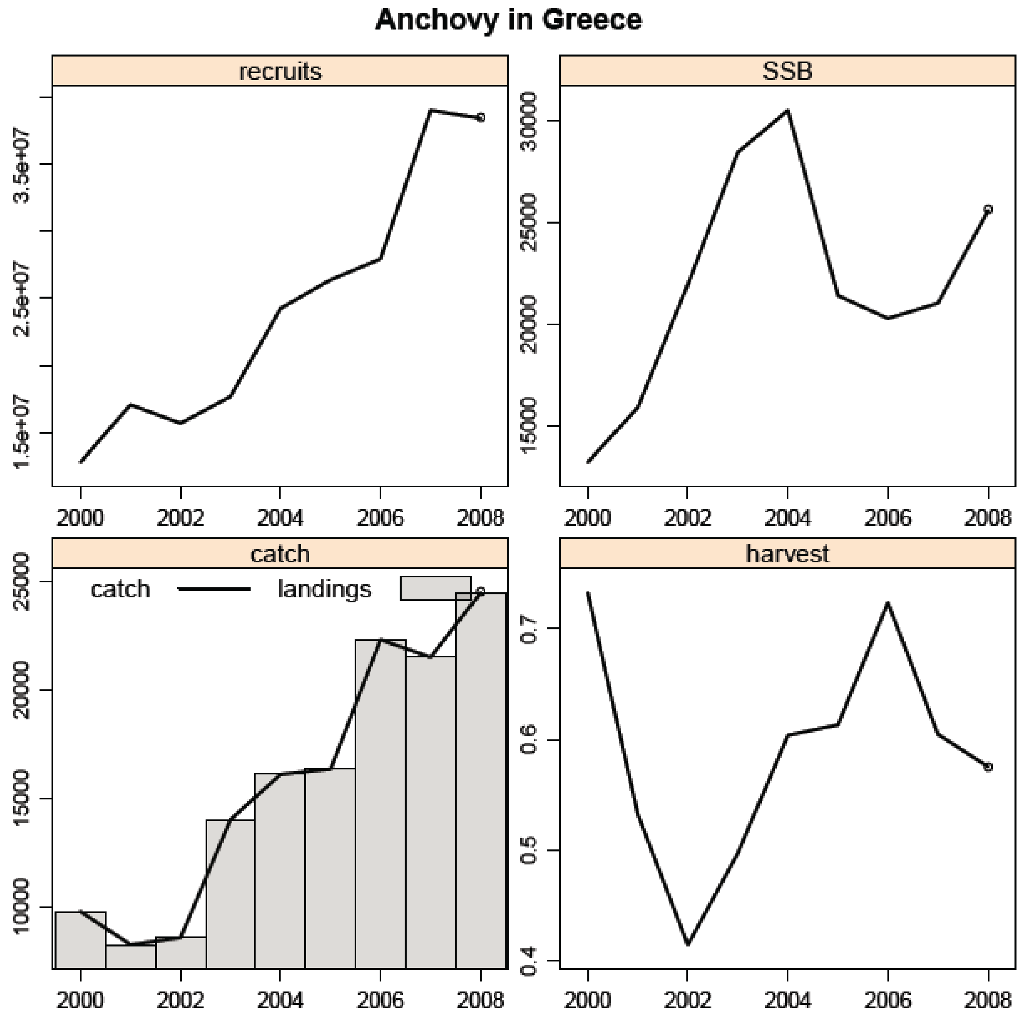
Table of limit and target management reference points or levels **agreed by fisheries managers**

$F_{0.1}$ (age range)= ages 1-3	
F_{max} (age range)= ages 1-3	
F_{msy} (age range)=	
F_{pa} (F_{lim}) (age range)=	
B_{msy} (spawning stock)=	
B_{pa} (B_{lim}, spawning stock)=	

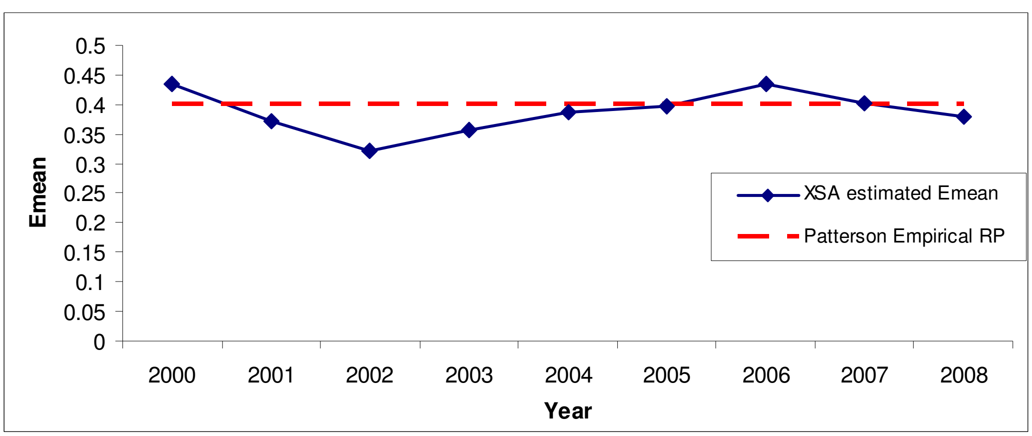
The summary output of the FLXSA model.

Year	Recruits	Spawning Biomass (tonnes)	Landings (tonnes)	Yield/SSB ratio	F 1-3	E 1-3
2000	12786927	13246	9762	0.737	0.732	0.434
2001	17067680	15940	8232	0.516	0.532	0.371
2002	15682110	21989	8549	0.389	0.415	0.321
2003	17676861	28482	14002	0.492	0.498	0.357
2004	24252908	30546	16099	0.527	0.604	0.385
2005	26392228	21439	16347	0.762	0.613	0.396
2006	27949854	20315	22311	1.098	0.723	0.435
2007	39024315	21066	21500	1.021	0.605	0.402
2008	38441213	25622	24480	0.955	0.576	0.380

Discards were also included within this assessment representing however only 0.06 % of total landings.



Anchovy in Greece
recruits
SSB
catch
harvest
catch
landings
1.5e+07
2.5e+07
3.5e+07
15000
20000
25000
30000
10000
15000
20000
25000
0.4
0.5
0.6
0.7
2000
2002
2004
2006
2008



Emean
Year
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
XSA estimated Emean
Patterson Empirical RP

6 ToR A-E UPDATE AND ASSESS HISTORIC AND RECENT STOCK PARAMETERS (DETAILED ASSESSEMENTS)

The following section of the present report does provide detailed stock specific assessments and all relevant data of such stocks and their fisheries. Unlike earlier years, the assessments are presented in geographic order by GSA, and not any longer by species. The format of the assessments has been agreed by the experts in 2008. Short versions of the assessments of stocks and fisheries in the format of summary sheets are provided in the preceding section 5.1 in cases when the analyses resulted in an analytical assessment of the stock status.

6.1 Stock assessment of European hake in GSA 10

6.1.1 Stock identification and biological features

6.1.1.1 Stock Identification

The stock of European hake was assumed in the boundaries of the whole GSA 10, lacking specific information on stock identification. *M. merluccius* is with red mullet and deep-water pink shrimp a key species of fishing assemblages in the central-southern Tyrrhenian Sea (GSA 10). It is generally also ranked among species with higher abundance indices in the trawl surveys (e.g. Spedicato *et al*., 2003). It is a long lived fish mainly exploited by trawlers, especially on the continental shelves of the Gulfs (e.g. Gaeta, Salerno, Palermo) but also by artisanal fishers using fixed gears (gillnets, bottom long-line).

Trawl-survey data have evidenced highest biomass indices on the continental shelf of the GSA 10 (100-200 m; Spedicato et al., 2003), where juveniles (less than 12 cm total length) are mainly concentrated. During autumn trawl surveys, one of the main recruitment pulses of this species is observed. Two main recruitment events (in spring and autumn; Spedicato et al. 2003) are reported in GSA 10 as for other Mediterranean areas (Orsi Relini *et al*., 2002). European hake is considered fully recruited to the bottom at 10 cm TL (from SAMED, 2002). The length structures from trawl surveys are generally dominated by juveniles, while large size individuals are rare. This pattern might be also due to the different vulnerability of older fish (Abella and Serena, 1998) beside the effect of high exploitation rates. The few large European hake caught during trawl surveys are generally females and inhabit deeper waters. The overall sex ratio (~0.41-0.47) estimated from trawl survey data is slightly skewed towards males.

6.1.1.2 Growth

Estimates of growth parameters were achieved during the SAMED project (SAMED, 2002) by the analysis of length frequency distributions. The following von Bertalanffy parameters were estimated by sex: females L_∞=74.2 cm; K=0.178; t_0= -0.20; males: L_∞=46.3cm; K=0.285; t_0= -0.20. In the DCF framework the growth has been studied ageing fish by otolith readings using the whole sagitta and thin sections for older individuals. Length frequency distributions were also analyzed using techniques as Batthacharya for separation of modal components. The observed maximum length of European hake was 83 cm for females and 58 cm for males both registered in the landings (bottom long-lines). Von Bertalanffy growth parameters for each sex were estimated from average length at age using an iterative non-liner procedure that minimizes the sum of the square differences between observed and expected values (excel): females: L_∞=97.9 cm, K=0.135, t_0= -0.4; males: L_∞=50.8 cm, K=0.25, t_0= -0.4. Parameters of the length-weight relationship were a=0.00350, b=3.2 for females and a=0.0086, b=3.215 for males, for length expressed in cm (Fig. 6.1.1.2.1)

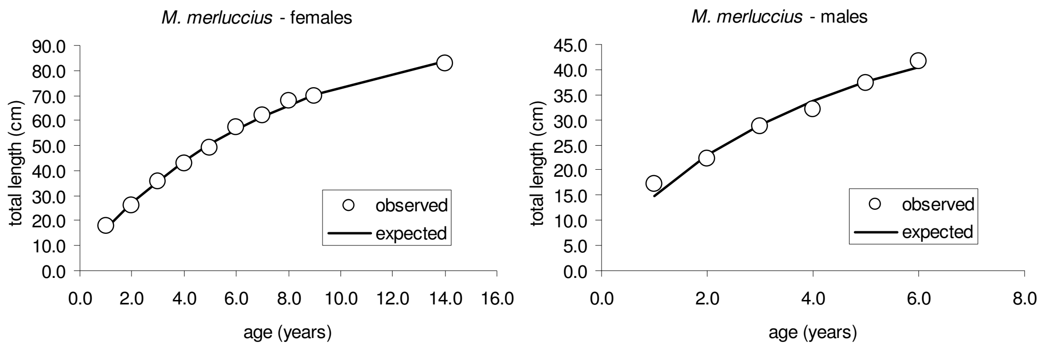


Fig. 6.1.1.2.1. Bertalanffy growth functions for female and male of hake in the GSA 10.

6.1.1.3 Maturity

A proxy of size at first maturity was estimated in the SAMED project (SAMED, 2002) using the average length at stage 2 (females with gonads at developing stage) that indicates an average length of about 30 cm. According to the data obtained in the DCF of 2008, the proportion of mature females (fish belonging to the maturity stage 2b onwards macroscopically classified using a 8 stage scale (Medits-Handbook_2007.v5) by length class in the period 2006-2008 is reported in the table below together with the estimated maturity ogive which indicates a $L_{m50\%}$ of about 33 cm (±0.27 cm) (Fig. 6.1.1.3.1). These estimates are similar to those of 2003-2005 (Lm50%=32.9±0.8; MR=6.4±0.9).

Proportion of mature females			
TL (cm)	p	TL (cm)	p
20	0.023	29	0.243
21	0.021	30	0.403
22	0.011	31	0.37
23	0.012	32	0.483
24	0.06	33	0.563
25	0.091	34	0.667
26	0.114	35	0.722
27	0.063	36	0.903
28	0.164	37	0.735

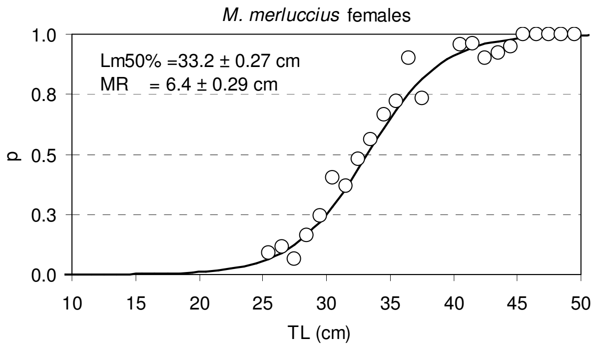


Fig. 6.1.1.3.1. Maturity ogive and proportions of mature female of hake in the GSA 10 (MR indicates the difference $Lm_{75\%}$-$Lm_{25\%}$).

The sex ratio is about 1:1 up to the size of 35 cm, after females are prevailing (Fig. 6.1.1.3.2).

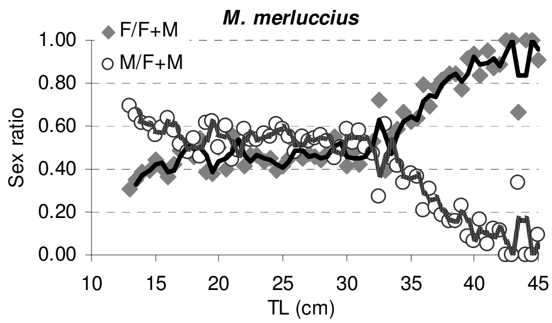


Fig. 6.1.1.3.2. Sex ratio for females and males by length.

6.1.2 Fisheries

6.1.2.1 General description of the fisheries

European hake is mostly targeted by trawlers, but also by small scale fisheries using nets and bottom long-lines. Fishing grounds are located on the soft bottoms of continental shelves and the upper part of continental slope along the coasts of the whole GSA. Catches from trawlers are from a depth range between 50-60 and 500 m and hake occurs with other important commercial species as *Illex coindetii*, *M. barbatus*, *P. longirostris*, *Eledone* spp., *Todaropsis eblanae*, *Lophius* spp., *Pagellus* spp., *P. blennoides*, *N. norvegicus*.

6.1.2.2 Management regulations applicable in 2010

Management regulations are based on technical measures, closed number of fishing licenses for the fleet and area limitation (distance from the coast and depth). In order to limit the over-capacity of fishing fleet, the Italian fishing licenses have been fixed since the late eighties. Other measures on which the management regulations are based regard technical measures (mesh size) and minimum landing sizes (EC 1967/06).

After 2000, in agreement with the European Common Policy of Fisheries, a gradual decreasing of the fleet capacity was implemented. Along northern Sicily coasts two main Gulfs (Patti and Castellammare) have been closed to the trawl fishery up 200 m depth, since 1990. In the GSA 10 the fishing ban has not been mandatory along the time, and from one year to the other it was adopted on a voluntary basis by fishers, whilst in the last years it was mandatory. Regarding long-lines the management regulations are based on technical measures related to the number of hooks and the minimum landing sizes (EC 1967/06), besides the regulated number of fishing licences.

In 2008 a management plan was adopted, that foresaw the reduction of fleet capacity associated with a reduction of the time at sea. Two biological conservation zone (ZTB) were permanently established in 2009 (Decree of Ministry of Agriculture, Food and Forestry Policy of 22.01.2009; GU n. 37 of 14.02.2009). One is located along the mainland, in front of Sorrento peninsula in the vicinity of the MPA of Punta Campanella (Napoli Gulf, 60 km^2, within 200 m depth) and a second one is along the coasts of Amantea (Calabrian coasts, 75 km^2 up to 250 m depth). In these areas trawling is forbidden and other fishing activities are allowed under permission. Since June 2010 the rules implemented in the EU regulation (EC 1967/06) regarding the cod-end mesh size and the operative distance of fishing from the coasts are enforced.

6.1.2.3 Catches

6.1.2.3.1 Landings

Available landing data are from DCF regulations. EWG 11-12 received Italian landings data for GSA10 by fishing gears which are listed in Table 6.1.2.3.1.1.

Since 2004, landings of hake increased from 1,338 t to 1,544 t in 2006, decreased to about 1,091 t in 2009 and increased to about 1291 t in 2010. Most part of the landings of hake is from trawlers and nets (GNS and GTR), but the catches of the demersal long-line fishery are also important.

Table 6.1.2.3.1.1. Annual landings (t) by major gear type, 2004-2010.

Species	GEAR	FISHERY	2004	2005	2006	2007	2008	2009	2010
HKE	GND	SPF	7		12	11	8	9	
HKE	GNS	DEMF	177	294	323	213	311	282	431
HKE	GTR	DEMSP	202	124	152	157	68	107	202
HKE	LLS	DEMF	266	269	288	240	232	247	184
HKE	OTB	DWSP			14	4	3	8	
HKE	OTB	DEMSP	186		97	173	351	277	
HKE	OTB	MDDWSP	300	612	649	464	147	156	
HKE	OTB								475
HKE	PS	SPF	1		2				

6.1.2.3.2 Discards

The discards of hake in the GSA 10 are reported for 2006, 2009 and 2010 being about 25 tons, 106.6 tons and 70 tons respectively.

6.1.2.3.3 Fishing effort

The trends in fishing effort by year and major gear type is listed in Table 6.1.2.3.3.1. The total fishing effort in kWdays from 2004 to 2010 is decreasing.

Table 6.1.2.3.3.1 Trend in fishing effort (kW*days) for the GSA 10 by fleet level, 2004-2010.

Area	Gear	Fishery	2004	2005	2006	2007	2008	2009	2010	Total
			5212242	3873979	3255356	2531896	1924958	2018775	1426305	20243511
		CEP	599410	425518	412143	342733	788684	1114012	613164	4295664
		DEMSP	704007	202984	114568	33279	123312	23990	171509	1373649
		FINF	1696	3455	1767	18469			1928	27315
	DRB	MOL	86117	294424	312180	144186	241664	188909	206550	1474030
	FPO	DEMSP	0	312076	148868					460944
	GND	SPF	281464	128070	622561	442465	470435	440882	103959	2489836
	GNS	DEMSP	4047979	5028180	2953928	2052278	2467212	2544508	2520971	21615056
		SLPF	1556			94137	1910	30214	12173	139990
SA 10	GTR	DEMSP	3374829	1739878	4295352	3854825	3105046	2480175	2522528	21372633
	LLD	LPF	1044137	1135956	791936	404235	353211	1287002	1660409	6676886
	LLS	DEMF	4563483	1810269	1434965	1194701	1316931	885225	973619	12179193
	LTL	LPF	0							0
	OTB	DEMSP	3648016	72338	1491604	1528297	3743680	3482911	3576824	17543670
		DWSP			246152	82495	116434	239720	289440	974241
		MDDWSP	4422360	7956395	5762828	5676419	2382266	2563895	1809087	30573250
	PS	LPF	1254287	807500	96501	186494	243450	1076308	475177	4139717
		SPF	3330804	2173517	1844148	1807146	973629	1623539	1075689	12828472
	PTB	SPF	6173							6173

6.1.3 Scientific surveys

6.1.3.1 Medits

6.1.3.1.1 Methods

According to the MEDITS protocol (Bertrand *et al*., 2002), trawl surveys were yearly (May-July) carried out, applying a random stratified sampling by depth (5 strata with depth limits at: 50, 100, 200, 500 and 800 m; each haul position randomly selected in small sub-areas and maintained fixed throughout the time). Haul allocation was proportional to the stratum area. The same gear (GOC 73, by P.Y. Dremière, IFREMER-Sète), with a 20 mm stretched mesh size in the cod-end, was employed throughout the years. Detailed data on the gear characteristics, operational parameters and performance are reported in Dremière and Fiorentini (1996). Considering the small mesh size a complete retention was assumed. All the abundance data (number of fish per surface unit) were standardized to square kilometer, using the swept area method.

Based on the DCF data call, abundance and biomass indices were recalculated. In GSA 10 the following number of hauls was reported per depth stratum (Table 6.1.3.1.1.1).

Table 6.3.3.1.1.1. Number of hauls per year and depth stratum in GSA 10, 1994-2010.

GSA 10	Year																
Stratum	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
10-50 m	7	8	8	8	8	8	8	8	6	7	7	7	7	7	7	7	7
50-100 m	10	10	10	10	10	10	10	10	9	8	8	8	8	8	8	8	8
100-200 m	17	17	17	17	17	17	17	17	14	14	14	14	14	14	14	14	14
200-500 m	22	22	22	22	22	22	22	24	18	18	18	18	18	18	19	18	18
500-800 m	28	28	28	28	28	27	28	26	23	23	23	23	23	23	22	23	23
Total	84	85	85	85	85	84	85	85	70	70	70	70	70	70	70	70	70

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in the GSA:

$$Yst = \Sigma\ (Yi*Ai)\ /\ A$$

$$V(Yst) = \Sigma\ (Ai^2 * si^2 / ni)\ /\ A^2$$

Where:

A=total survey area

Ai=area of the i-th stratum

si=standard deviation of the i-th stratum

ni=number of valid hauls of the i-th stratum

n=number of hauls in the GSA

Yi=mean of the i-th stratum

Yst=stratified mean abundance

V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien *et al*. 2004).

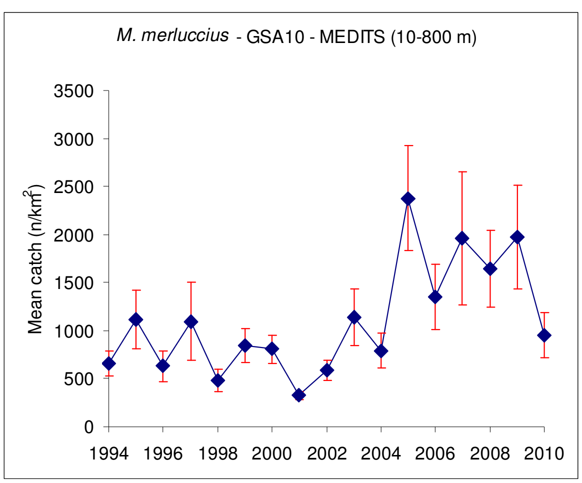
Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

6.1.3.1.2 Geographical distribution patterns

The geographical distribution pattern of European hake has been studied in the area using trawl-survey data and applying geostatistical methods. In these studies both the total abundance indices (Lembo et al., 1998a) and the abundance indices of recruits were analysed (Lembo *et al*., 1998b, 2000). The higher concentration of recruits in the GSA 10 were localised in the northern side (Gulfs of Napoli and Gaeta). Recent estimations have confirmed the presence of important zone for recruits in the northernmost part of the GSA, although sites with a high probability of locating a nursery appeared also along the coasts of southern part of the mainland and North Sicily. From GRUND data (autumn survey) the higher abundance of recruits were instead localised in the central part of the GSA, along the mainland coasts. Persistence of the nursery areas along the time was estimated from the indicator kriging (SGMED 09-02).

6.1.3.1.3 Trends in abundance and biomass

Fishery independent information regarding the state of the hake in GSA 10 was derived from the international survey MEDITS. Figure 6.1.3.1.3.1 displays the estimated trend of hake abundance and biomass indices standardized to the surface unit in the GSA10. Indices from MEDITS trawl-surveys show an increasing pattern up to 2009, although variability is high, and a decrease in 2010 (Figure 6.1.3.1.3.1).



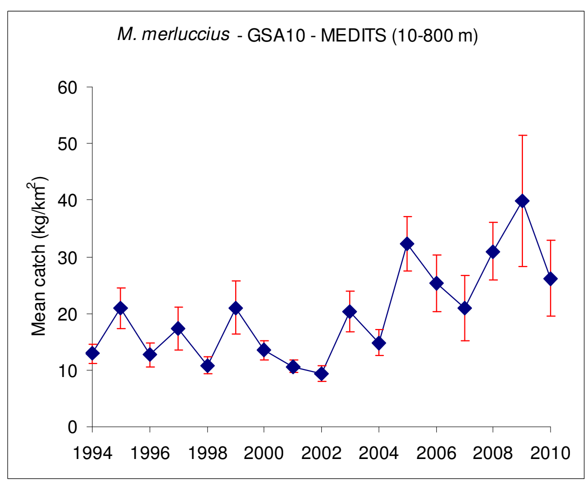


Fig. 6.1.3.1.3.1. Trends in survey abundance and biomass derived from MEDITS (bars indicate standard deviation).

The re-estimated abundance and biomass indices (Figure 6.1.3.1.3.2) also reveal increasing trends since 2002. However, the recent high abundance and biomass indices are subject to high uncertainty.

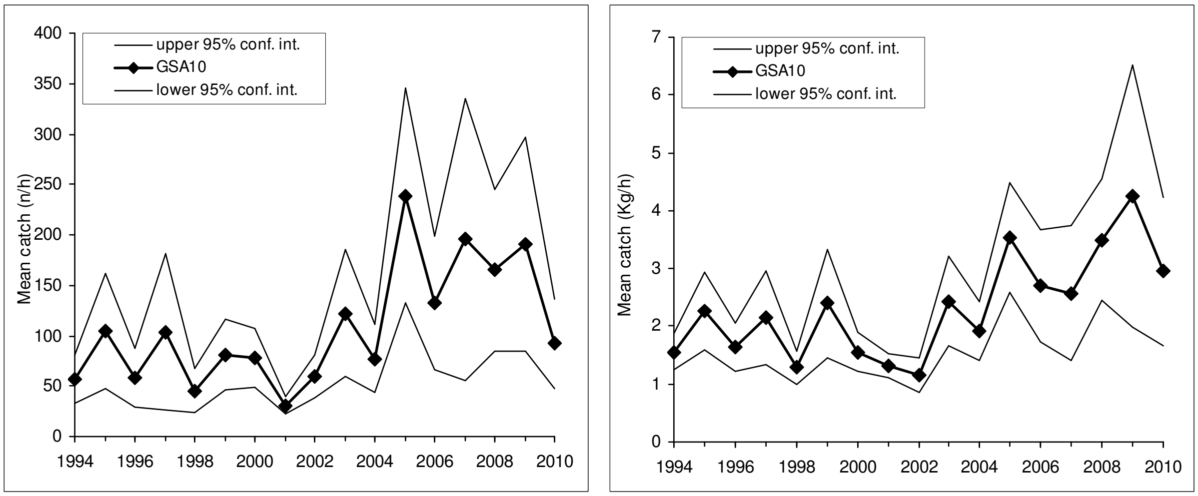


Fig. 6.1.3.1.3.2. Abundance and biomass indices of hake in GSA 10.

6.1.3.2 Grund

6.1.3.2.1 Methods

Since 2003 Grund surveys (Relini, 2000) was conducted using the same vessel and gear in the whole GSA. Sampling scheme, stratification and protocols were similar as in MEDITS. All the abundance data (number of fish and weight per surface unit) were standardised to square kilometer, using the swept area method.

6.1.3.2.2 Geographical distribution patterns

Mapping of the hake recruits obtained applying the indicator kriging technique with contouring that represents probability (in percentage) is reported in the STECF_SGMED 02 2009 report.

Trends derived from the GRUND surveys are shown in Figure 6.1.3.2.2.1. Abundance indices increased significantly ($p<0.05$ on ln-transformed data), as well as recruitment indices, while biomass indices were almost stationary.

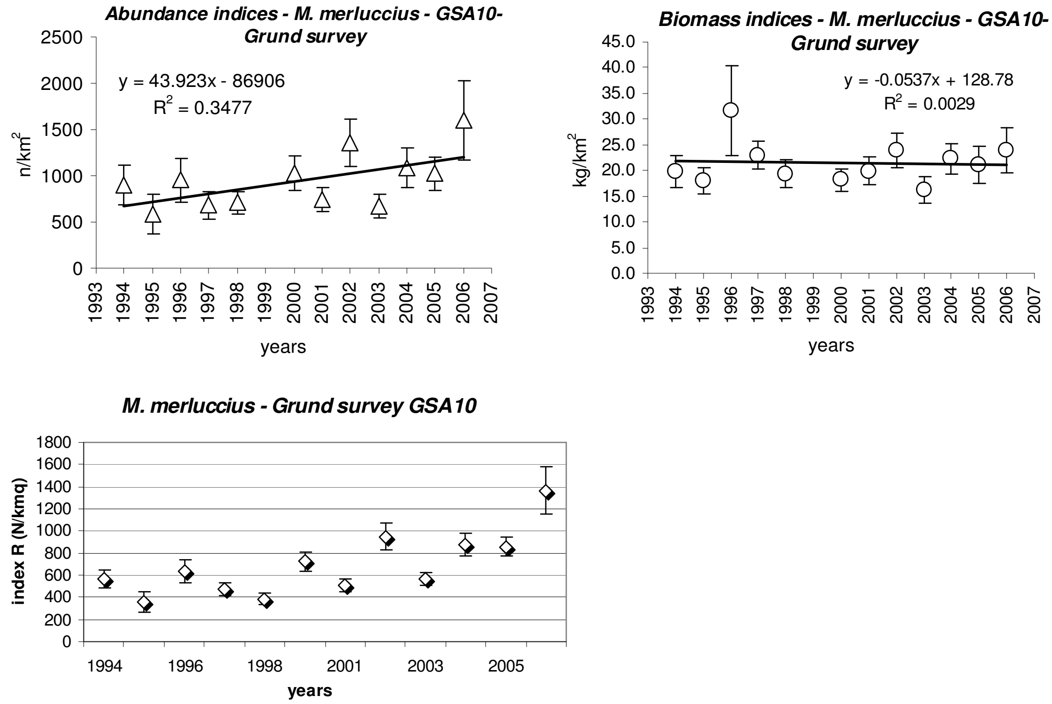


Fig. 6.1.3.2.2.1. Abundance and biomass indices of hake in GSA10 derived from GRUND surveys. Recruitment indices (N/km^2) with standard deviation are also reported.

6.1.3.2.3 Trends in abundance by length or age

No trend in the mean length was observed in MEDITS survey (Figure 6.1.3.2.3.1), nor at the third quantile lengths, as obtained from the length structures of GRUND time series from 1994 to 2006 (Figure 6.1.3.2.3.2). However the mean length of older fish is reduced along the time.

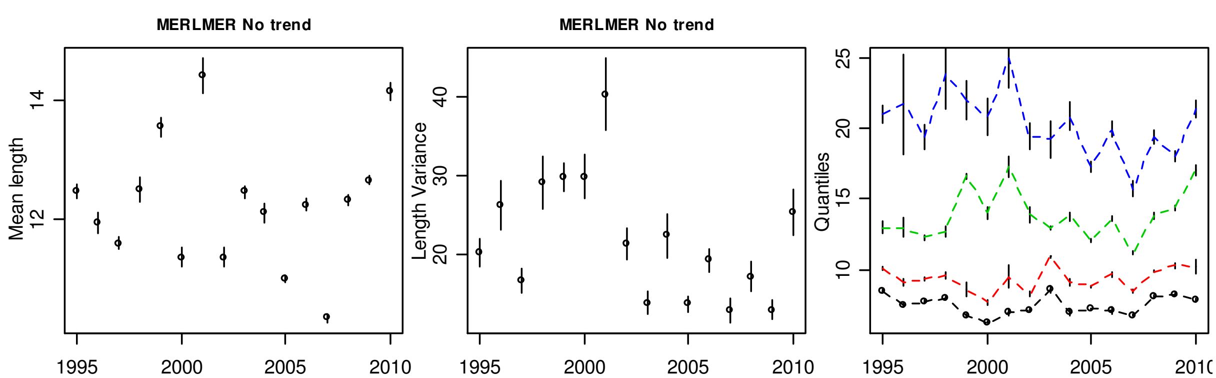


Fig. 6.1.3.2.3.1. Mean length, variance and quantiles derived from the MEDITS length compositions.

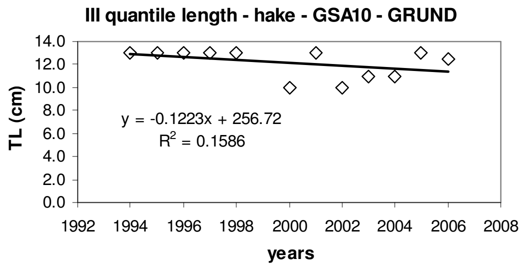


Fig. 6.1.3.2.3.2. III Quantile derived from the GRUND length structures in 1994-2006.

The following Fig. 6.1.3.2.3.3, 6.1.3.2.3.4 and 6.1.3.2.3.5 display the stratified abundance indices of GSA 10 in 1994-2001, 2002-2009 and 2010.

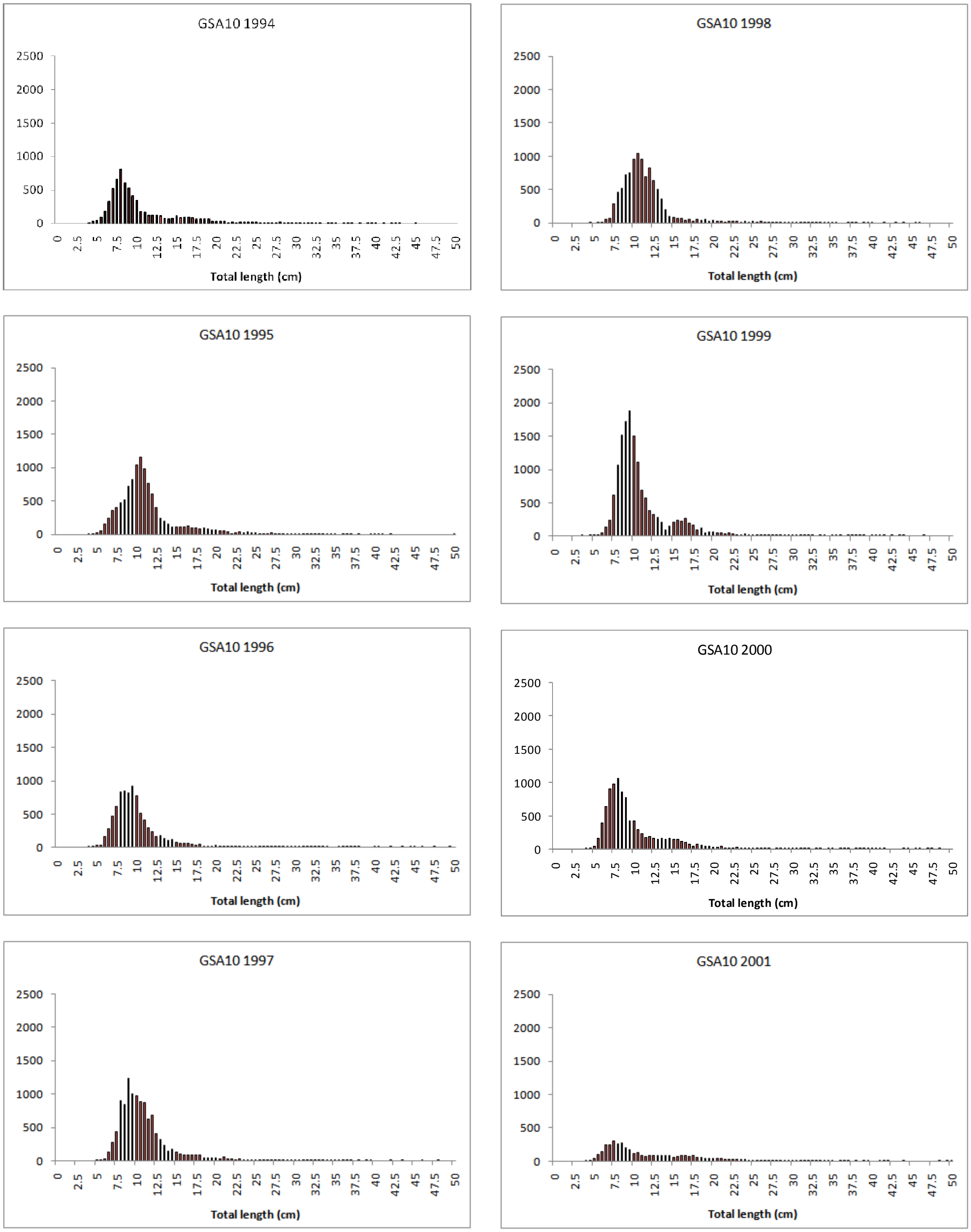


Fig. 6.1.3.2.3.3. Stratified abundance indices by size, 1994-2001.

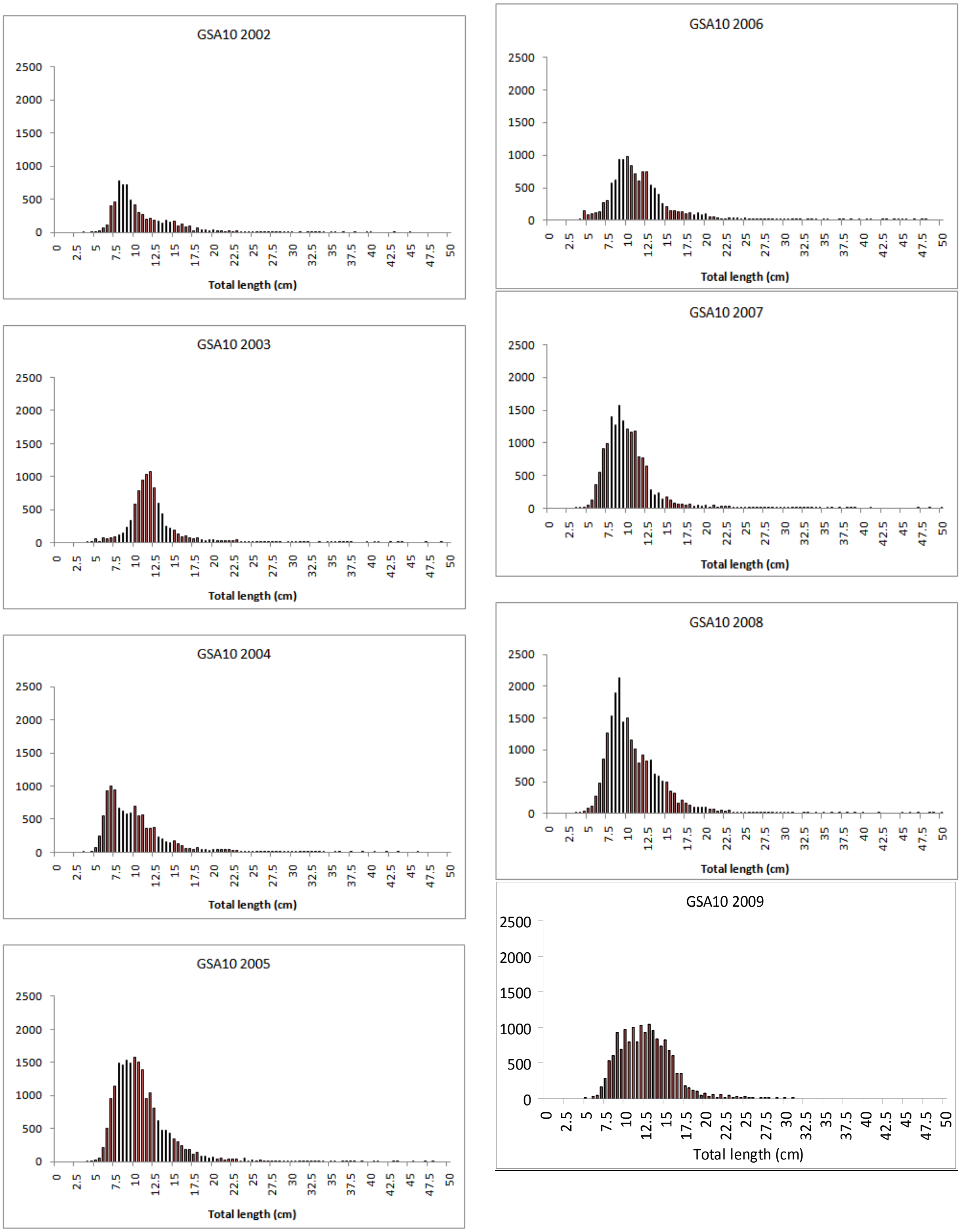


Fig. 6.1.3.2.3.4. Stratified abundance indices by size, 2002-2009.

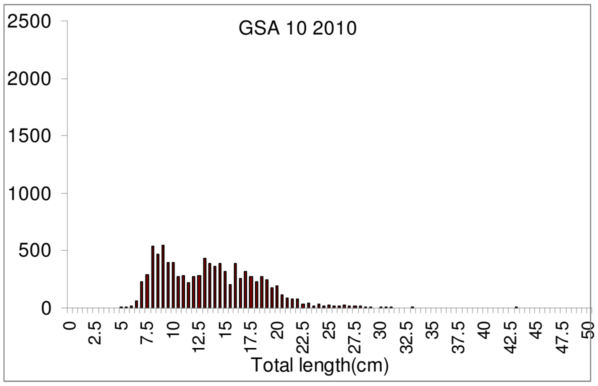


Fig. 6.1.3.2.3.5. Stratified abundance indices by size, 2010.

6.1.3.2.4 Trends in growth

No analyses were conducted.

6.1.3.2.5 Trends in maturity

No analyses were conducted.

6.1.4 Assessment of historic stock parameters

6.1.4.1 Method 1: Surba

6.1.4.1.1 Justification

SURBA software was applied using MEDITS abundance estimates by length. Two scenarios based on a different growth pattern were used to account for uncertainty in the growth of the species.

6.1.4.1.2 Input parameters

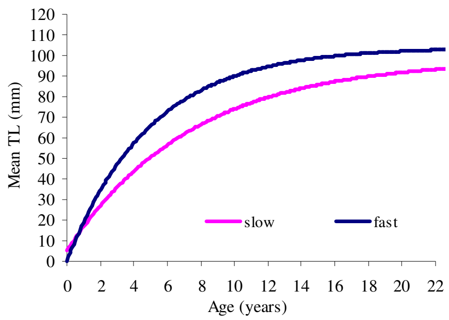
Two sets of growth parameters were used in the analyses to split the LFDs after that these were raised to the square km and averaged over the area for the SURBA analyses.

<u>Set 1) 'slow' growth</u>

L_∞=97.9 cm, K=0.135, t_0= -0.4; males: L_∞=50.8 cm, K=0.25, t_0= -0.4; length-weight relationship: a=0.00355, b=3.22 for sex combined.

Set 2) 'fast' growth

L_∞=104 cm, K=0.2, t_0= -0.01; length-weight relationship: a=0.00355, b=3.22 for sex combined. Length at age and graphs of the growth curves according to the two sets are reported in the figure and table below.



growth	slow	fast
age (years)	mean length (cm)	mean length (cm)
0	5.03	0.21
1	16.77	19.02
2	27.03	34.43
3	35.99	47.04
4	43.82	57.36
5	50.66	65.82
6	56.64	72.74
7	61.86	78.41
8	66.43	83.04
9	70.41	86.84
10	73.90	89.95

Fig. 6.1.4.1.2.1. Growth scenarios used in the assessment

The age groups derived from the age slicing are reported in the tables below. Age slicing was conducted on separate sex in the case of 'slow' parameter set and numbers were afterward combined. A 5+ group and a 4+ group were respectively used for the two data sets.

Table 6.1.4.1.2.1. Age groups obtained after the age slicing procedure and used as input in SURBA

	'Slow' age groups						'fast' age groups				
Year	0	1	2	3	4	5+	0	1	2	3	4+
1994	563.51	74.39	11.31	2.87	0.17	0.41	600.13	48.68	3.44	0.20	0.20
1995	916.64	173.23	24.19	3.01	0.90	0.87	1018.48	97.56	2.47	0.14	0.24
1996	527.64	82.00	14.37	3.66	1.78	0.48	578.13	48.42	3.01	0.42	0.00
1997	962.58	117.24	13.63	2.77	0.50	0.24	1037.27	57.45	1.96	0.24	0.00
1998	392.85	64.03	17.94	2.49	1.11	0.47	421.57	54.70	2.52	0.00	0.15
1999	522.42	291.61	20.93	5.31	0.96	0.86	743.90	94.89	3.23	0.12	0.00
2000	671.73	113.18	13.96	4.15	1.49	0.39	746.04	54.43	3.81	0.60	0.04
2001	210.09	93.95	15.61	2.12	1.10	0.61	259.14	61.23	2.56	0.47	0.11
2002	481.19	89.02	9.68	1.65	0.77	0.00	544.55	36.29	1.40	0.00	0.00
2003	1001.80	118.53	16.97	3.84	0.86	0.28	1075.38	63.39	3.14	0.40	0.00
2004	667.90	107.93	12.52	2.90	0.27	0.58	732.65	57.54	1.31	0.00	0.41
2005	2213.21	148.39	13.69	1.60	0.35	0.54	2286.89	87.89	2.17	0.59	0.23
2006	1134.11	188.89	25.69	2.82	1.30	0.17	1249.96	100.14	2.32	0.51	0.00
2007	1883.49	66.88	8.42	0.86	0.85	0.42	1907.04	51.44	1.19	0.974	0.28
2008	1377.76	239.07	18.84	3.81	1.33	1.46	1544.23	93.24	2.94	1.50	0.39
2009	1770.11	187.63	11.04	0.15	0.17	0.47	1890.15	78.39	0.38	0.32	0.32
2010	695.59	237.97	11.47	1.25	0.31	0.70	812.73	132.25	1.47	0.30	0.56

The other settings of the model, regarding natural mortality, catchability, maturity and weight at age, are reported in the table below. Natural mortality vector for the two scenarios were obtained applying the Prodbiom method (Abella *et al*., 1997) and calculation sheet provided by the author.

Table 6.1.4.1.2.2 . SURBA settings related to the natural mortality (M), the catchability coefficient q, the proportion of mature and the weight at age in the slow and fast growth scenarios.

Age	0	1	2	3	4	5+
M (slow)	0.85	0.46	0.37	0.33	0.31	0.29
M (fast)	1.16	0.53	0.40	0.35	0.32	
Q (slow)	0.90	1.00	1.00	0.75	0.50	0.5
Q (fast)	0.90	1.00	1.00	0.75	0.50	
Proportion mature (slow)	0.01	0.31	0.97	1.00	1.00	1.00
Proportion mature (fast)	0.01	0.25	0.89	1.00	1.00	
Weight (kg) (slow)	0.01	0.07	0.20	0.41	0.67	1.81
Weight (kg) (fast)	0.01	0.15	0.56	1.23	3.50	

6.1.4.1.3 Results

Estimates of total mortality from SURBA, for sex combined and for slow and fast growth, are presented in Table 6.1.4.1.3.1.

Table 6.1.4.1.3.1. Relative estimates of total mortality Z and spawning stock biomass SSB from Surba, for sex combined and for slow and fast growth scenarios.

Slow growth pattern - Results					Fast growth pattern - Results			
	Original		Smoothed		Original		Smoothed	
Year	SSB	Z	SSB	Z	SSB	Z	SSB	Z
1994	0.675	1.202	0.747	1.271	0.891	3.091	0.857	2.81
1995	1.371	1.634	1.168	1.502	1.175	2.625	0.987	2.402
1996	0.939	1.81	1.073	1.583	0.789	2.868	0.888	2.518
1997	0.821	1.497	0.975	1.389	0.717	2.96	0.721	2.594
1998	0.864	1.096	1.149	1.427	0.788	2.937	0.829	2.473
1999	1.706	1.976	1.278	1.531	1.082	2.449	1.012	2.253
2000	0.99	1.731	1.103	1.692	0.958	2.575	1.029	2.595
2001	0.897	1.844	0.929	1.628	0.895	3.419	0.756	2.471
2002	0.614	1.078	0.747	1.418	0.469	1.85	0.639	1.971
2003	0.985	2.223	0.842	1.58	0.915	3.572	0.778	2.213
2004	0.831	2.079	0.904	1.681	0.875	2.038	0.974	2.341
2005	0.898	1.18	0.936	1.504	1.197	2.541	1.041	2.054
2006	1.32	2.569	1.085	1.661	1.134	2.65	1.347	2.164
2007	0.554	0.541	0.924	1.809	0.955	1.315	1.331	2.111
2008	1.612	3.673	1.049	2.041	1.631	3.86	1.262	2.52
2009	0.84	1.416	1.029	2.34	0.942	2.106	1.171	3.335
2010	1.085	NA	1.061	NA	1.588	NA	1.378	NA

In the slow growth hypothesis, the temporal trend of f and the mean F estimates in the age range 1-3 years showed an increasing pattern and a high variability as well as the estimates of SSB index. The retrospective analysis showed a sharp increase of recruitment. Residuals varied without any trend.

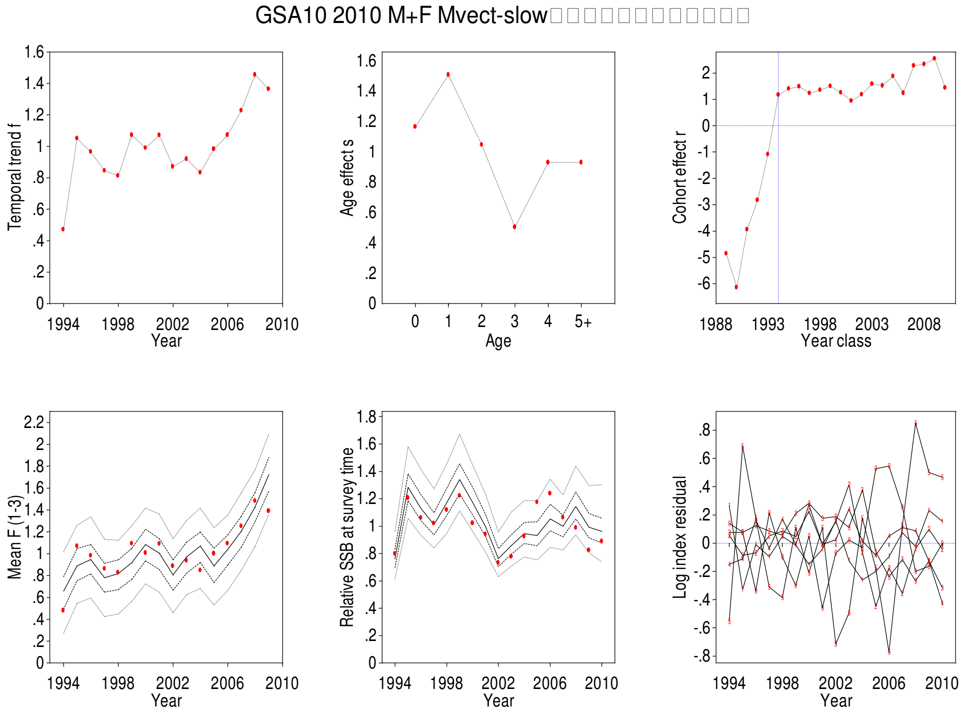


Fig. 6.1.4.1.3.1. Trends in various stock parameters from SURBA, hake in GSA10, slow growth pattern.

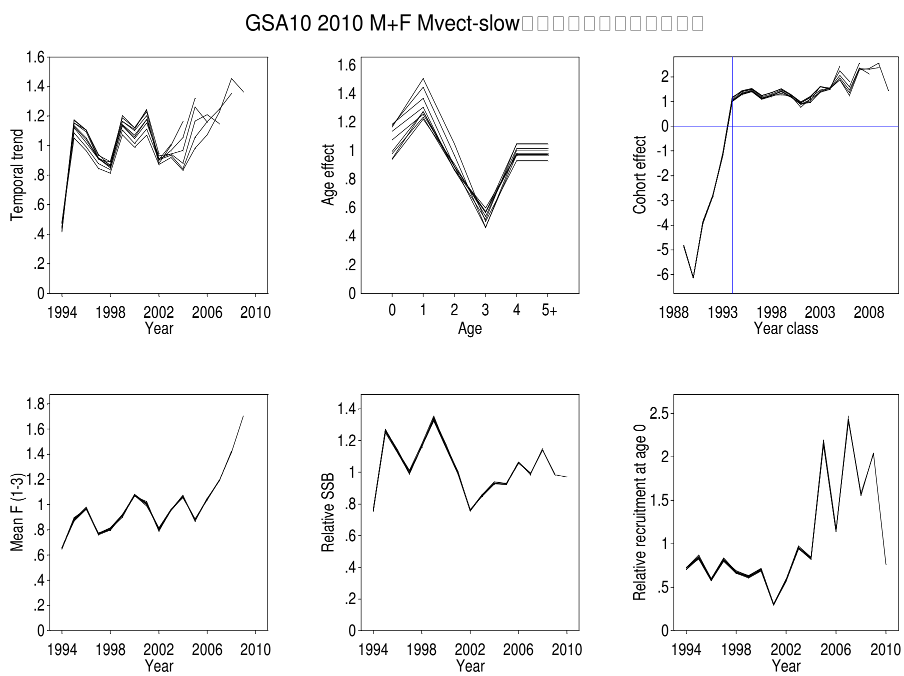


Fig. 6.1.4.1.3.2. Retrospective analysis from SURBA, hake in GSA10, slow growth pattern.

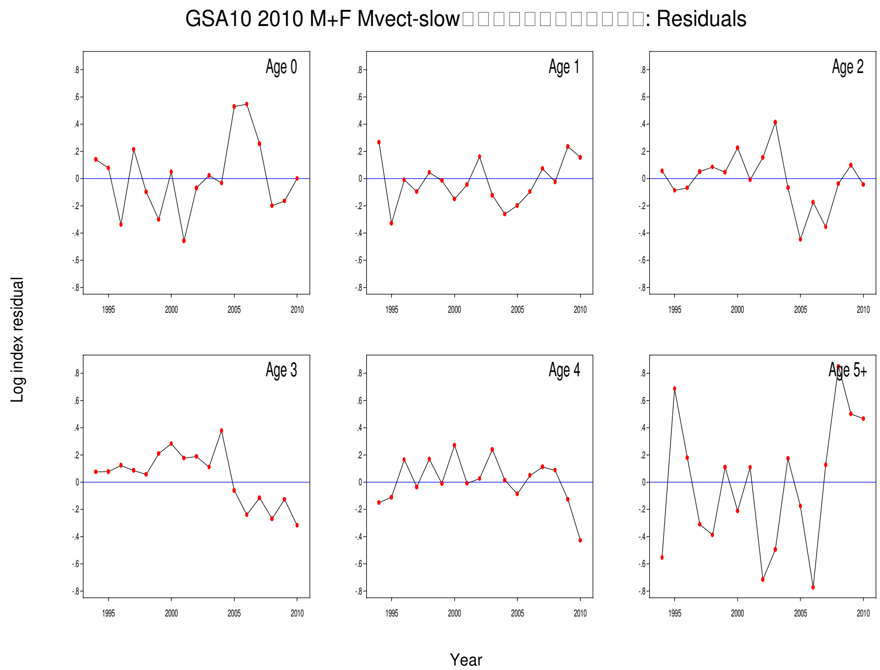


Fig. 6.1.4.1.3.3. Residuals from SURBA, hake in GSA10, slow growth pattern.

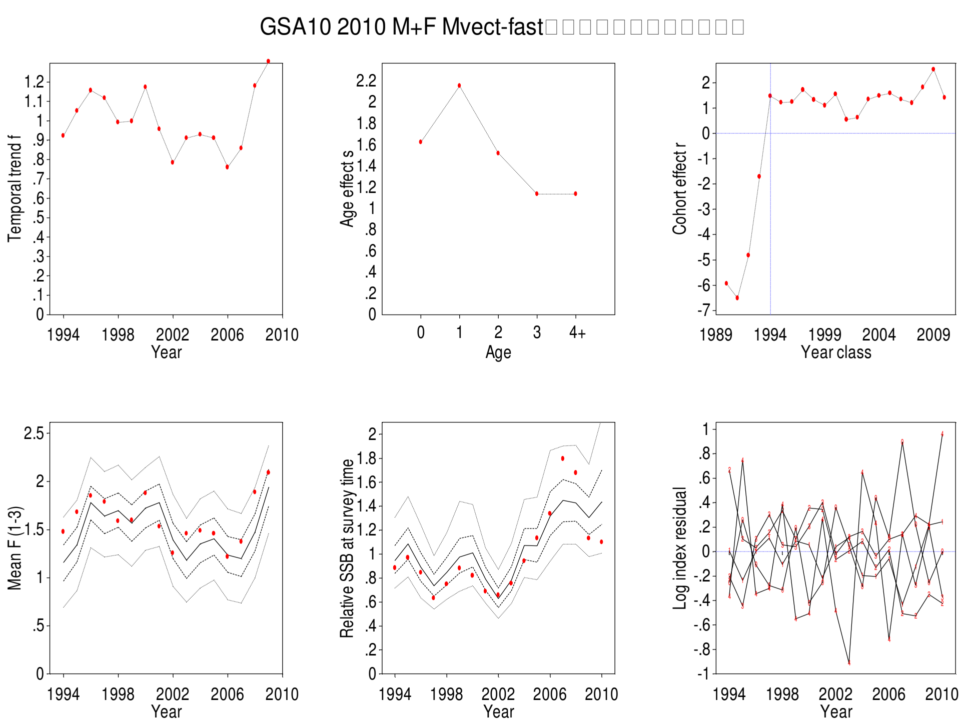


Fig. 6.1.4.1.3.4. Trends in various stock parameters from SURBA, hake in GSA10, fast growth pattern.

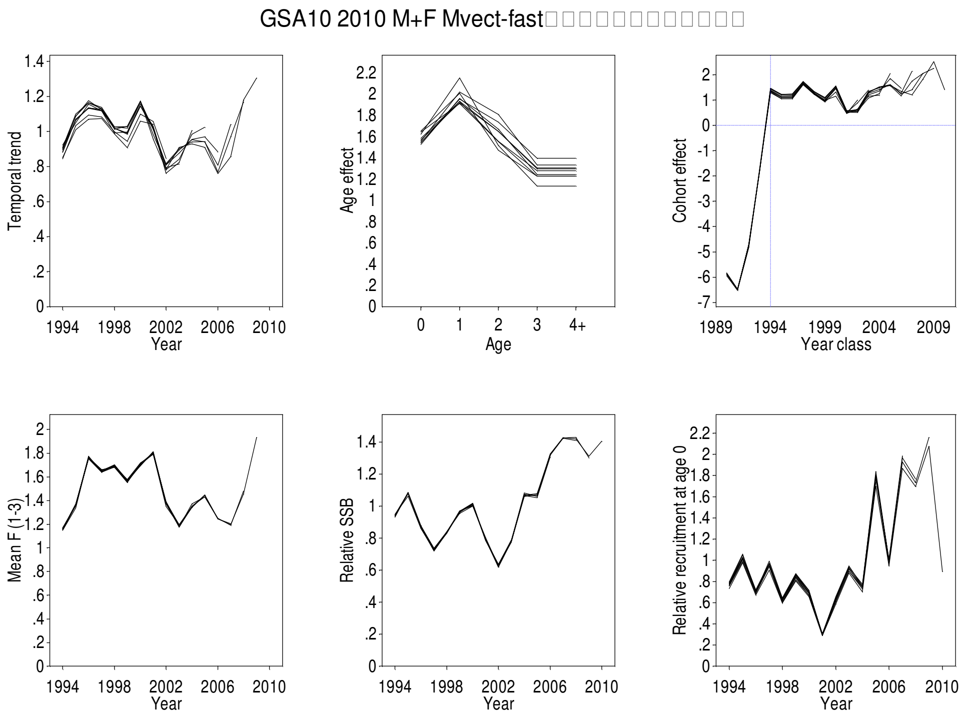


Fig. 6.1.4.1.3.5 Retrospective analysis from SURBA, hake GSA10, fast growth pattern.

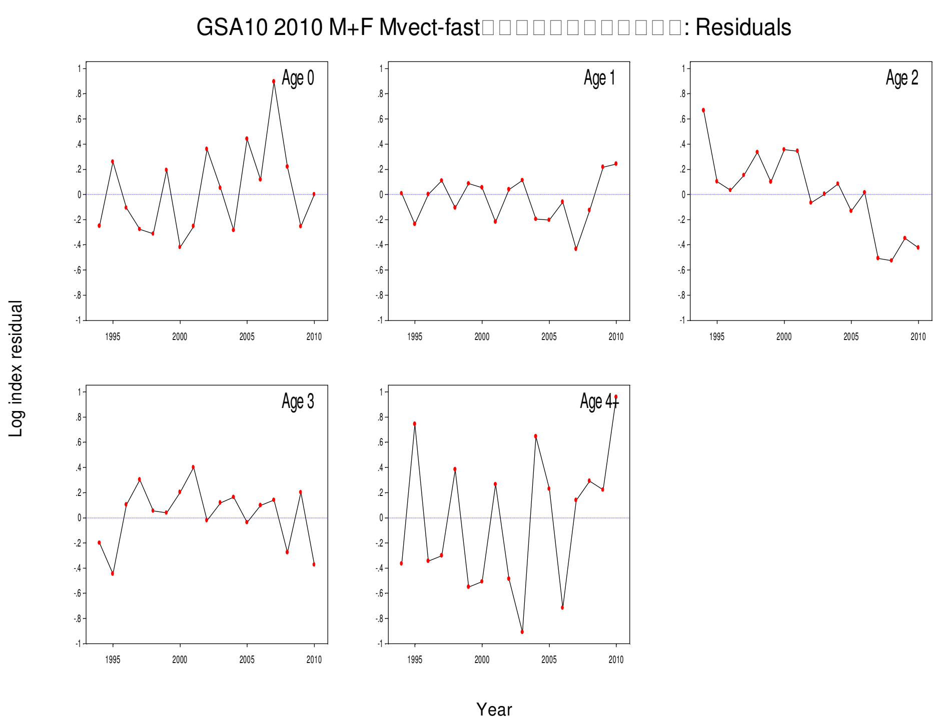


Fig. 6.1.4.1.3.6. Residuals from SURBA, hake in GSA10, fast growth pattern.

In the fast growth hypothesis, the temporal trend of F and the mean F estimates in the age range 1-3 showed a remarkable increasing pattern and a high variability as well as the SSB index estimates that showed a decreasing since 2006. The analysis showed also a sharp increase of recruitment. Residuals varied without any trend, except for age 2.

The overall (for the whole life span) fishing mortality rate has been calculated as geometric mean for the slow and fast growth pattern and is reported in the figure 6.1.4.1.3.7. In 2007 average F was about 1.2 for both the scenarios. In 2008 it was 1.4 and 1.7 for the slow and fast growth scenario respectively, while in 2009 it was 1.3 and 1.9, respectively.

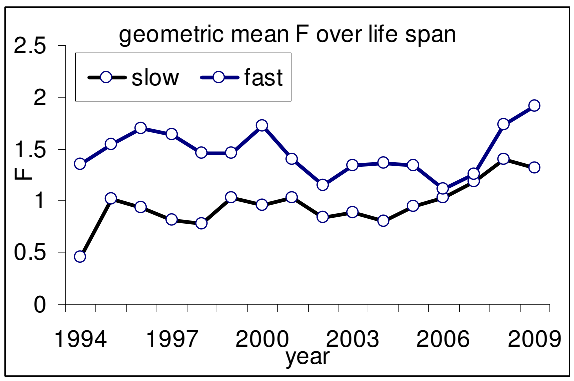


Fig. 6.1.4.1.3.7. Geometric mean of F from SURBA calculated over the life span for the fast and slow growth pattern of hake in GSA10.

6.1.4.2 Method 2: VIT

6.1.4.2.1 Justification

The cohort analysis and the Y/R approach as implemented in the VIT software under equilibrium conditions were used, as the time series of landings is short. The VIT analysis has been performed both for fast and slow growth scenarios. Discards were not considered in the analysis (< 10%).

6.1.4.2.2 Input parameters

The input parameters regarding age, maturity, natural mortality and length-weight relationship were those already reported for the SURBA inputs. The landing structures (in length and age) of 2006, 2007, 2008, 2009 and 2010 were from the EWG 11-12 data call (Table 6.1.4.1.3.2 and Table 6.1.4.1.3.3). For slow growth scenario the age structure of landings were from EWG 11-12 data call as well, while for fast growth scenario length frequency distributions of the landings were sliced using the fast growth parameters by means of an R routine (RAS, Routine for Age Slicing) performing age slicing following the algorithm by Hoggarth et al. (2006) with some modifications regarding time slice. The terminal fishing mortality F_{term} was set in the model equal to 0.32 for fast growth and 0.25 for slow growth scenario.

Table 6.1.4.2.2.1. Age distribution in catch used as input for VIT (fast growth scenario)

fast	2006			2007			2008			2009			2010		
Age	**OTB**	**LLS**	**NETS**	**OTB**	**LLS**	**NETS**	**OTB**	**LLS**	**NETS**	**OTB**	**LLS**	**NETS**	**OTB**	**LLS**	**NETS**
0	6866680	0	98253	10483280	0	15949	4475169	1591	3716	6719003	0	160963	2982631	0	525030
1	4867309	71836	2035589	2814954	0	1446642	2595349	123418	796236	2777530	319176	1234310	2898392	37756	2533489
2	124917	121445	321533	206443	28451	228007	149007	43673	185404	63349	123509	174312	82383	174476	567588
3	15472	83460	10331	10246	67816	15949	28763	54106	62616	3462	33938	24694	33342	24643	35898
4	7736	41077	6887	10246	39665	15949	10786	39201	29730	0	22064	12924	0	6825	0
5	7736	11284	0	0	15806	0	0	11722	7432	0	4000	7755	0	7565	0
6				0	3161	0	0	4774	0	0	4000	2585	0	5284	0
7										0	2786	0	0	1294	0
8										0	1214	0	0	1088	0
9													4763	0	0

Table 6.1.4.2.2.2. Age distribution in catch used as input for VIT (slow growth scenario)

slow	2006			2007			2008			2009			2010		
Age	**OTB**	**LLS**	**NETS**	**OTB**	**LLS**	**NETS**	**OTB**	**LLS**	**NETS**	**OTB**	**LLS**	**NETS**	**OTB**	**LLS**	**NETS**
0	4541370	0	17342	7594434	0	15949	2944402	0	3716	5877053	0	80428	2116766	0	155650
1	6375238	12139	1017506	5388967	0	761574	3652459	36801	266876	3031246	20919	402382	3236077	204	1669968
2	857754	72930	1218571	337570	0	723952	497846	98915	580685	606816	327474	966334	544218	49996	1227736
3	74457	88924	179201	152968	22128	173175	106840	25633	106377	44766	81481	99863	56819	149417	393365
4	10087	40053	30841	40985	12645	15949	32358	21171	58165	3462	23072	24483	23816	21237	59304
5	15472	55849	2246	0	50032	15949	14382	37963	32154	0	21740	18916	19052	15231	8975
6	0	31824	6888	10246	38771	15949	3595	24102	21172	0	14263	12212	0	4352	0
7	7736	18759	0	0	12356	0	7191	19264	8558	0	9738	2585	0	3264	0
8	7736	6950	0	0	3161	0	0	9477	0	0	4000	2585	0	4352	0
9	0	1675	0	0	12645	0	0	385	7432	0	0	5170	0	5123	0
10				0	2473	0	0	4774	0	0	4000	2585	0	2255	0
11				0	689	0				0	2667	0	0	1325	0
12										0	0	0	0	788	0
13										0	1333	0	0	300	0
14													0	1088	0
15													0	0	0
16													4763	0	0

6.1.4.2.3 Results

VIT results regarding the pattern of catch reconstruction by age, year and fishing level 4, and the total and fishing mortality by age and fishing level 4, are showed in the figure 6.1.4.2.3.1, 6.1.4.2.3.2, 6.1.4.2.3.3 and 6.1.4.2.3.4 for both growth scenarios. The total catch is mainly based on the fish aged 1, as result of the trawling targeting features, however age 1 and 2 are also important components of the catches of the set nets, like trammel net and gillnet. Age older than 2 are instead the major target of long-lines. The mortality acting on the age groups mirrors the pattern of the catches. The results for the fast growth scenario show a current fishing mortality changing from 0.76 in 2007 to 0.63 in 2010. The Yield per Recruit analyses indicate a current level of F that is on average 0.65, between the five years analyzed. In 2010 Fcurrent is 0.65. The reference point $F_{0.1}$ is on average 0.17 if the value of 2006 is excluded.

The results from the fast growth scenario were retained for the short and medium terms forecasts.

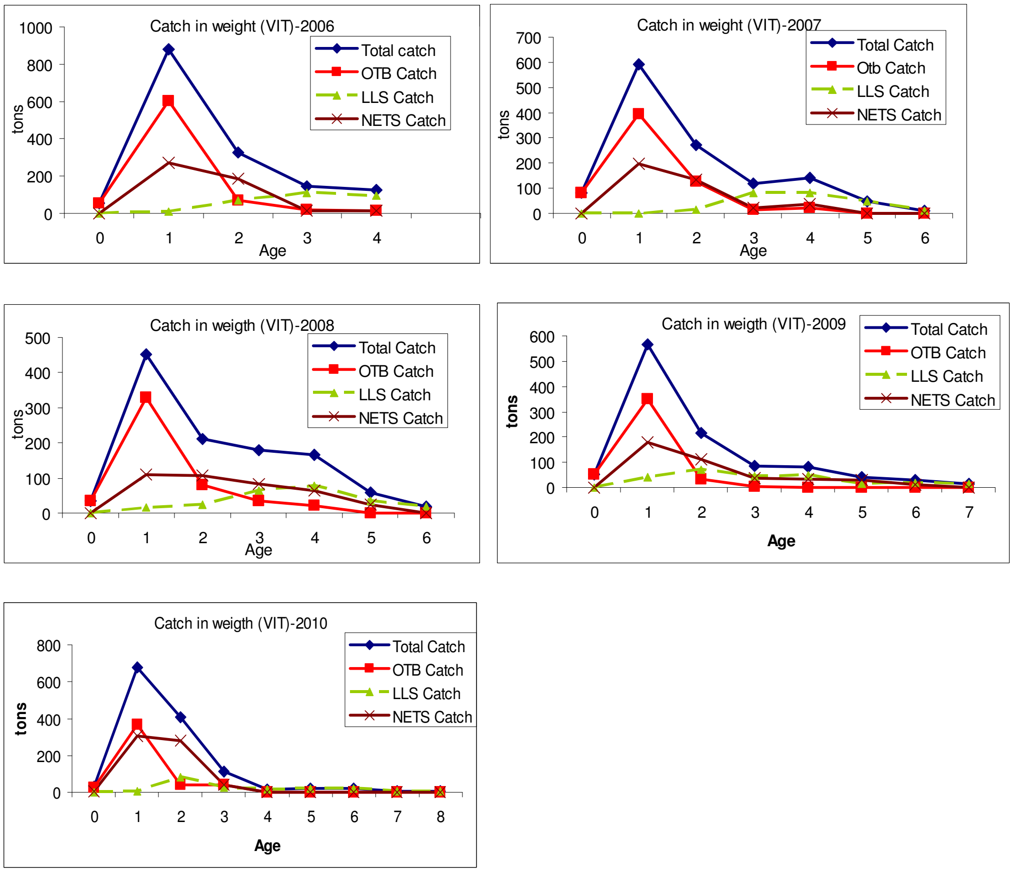
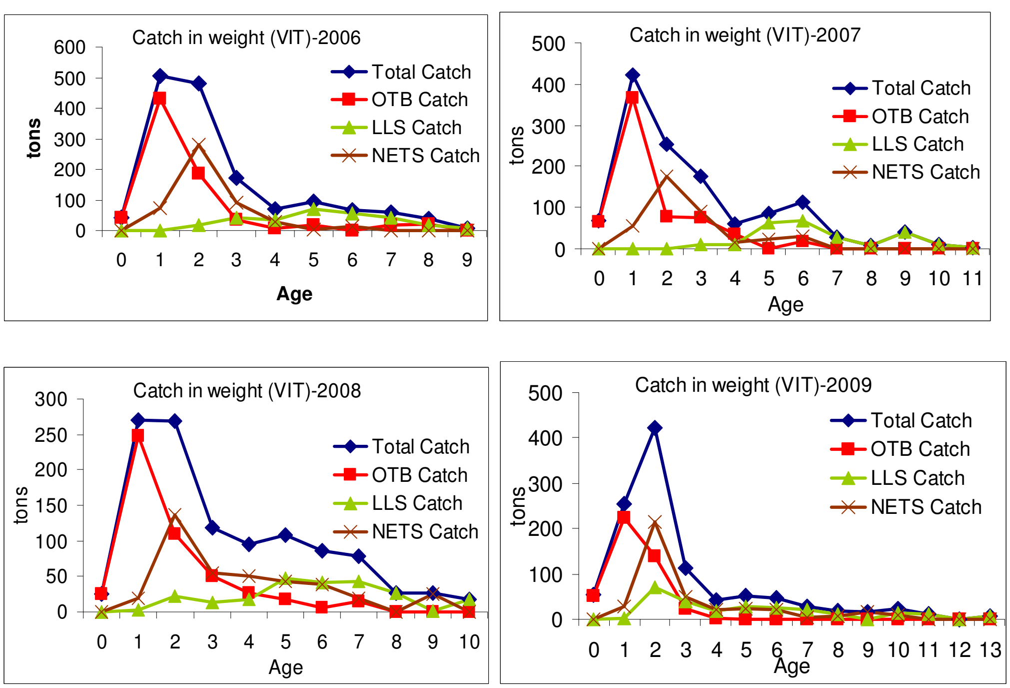


Fig. 6.1.4.2.3.1. Catch at age by year and fishing gear. Fast growth scenario.



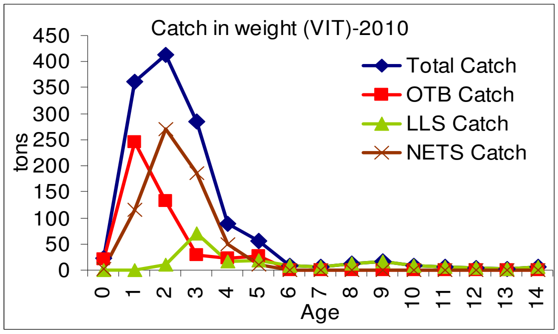


Fig. 6.1.4.2.3.2. Catch at age by year and fishing gear. Slow growth scenario.

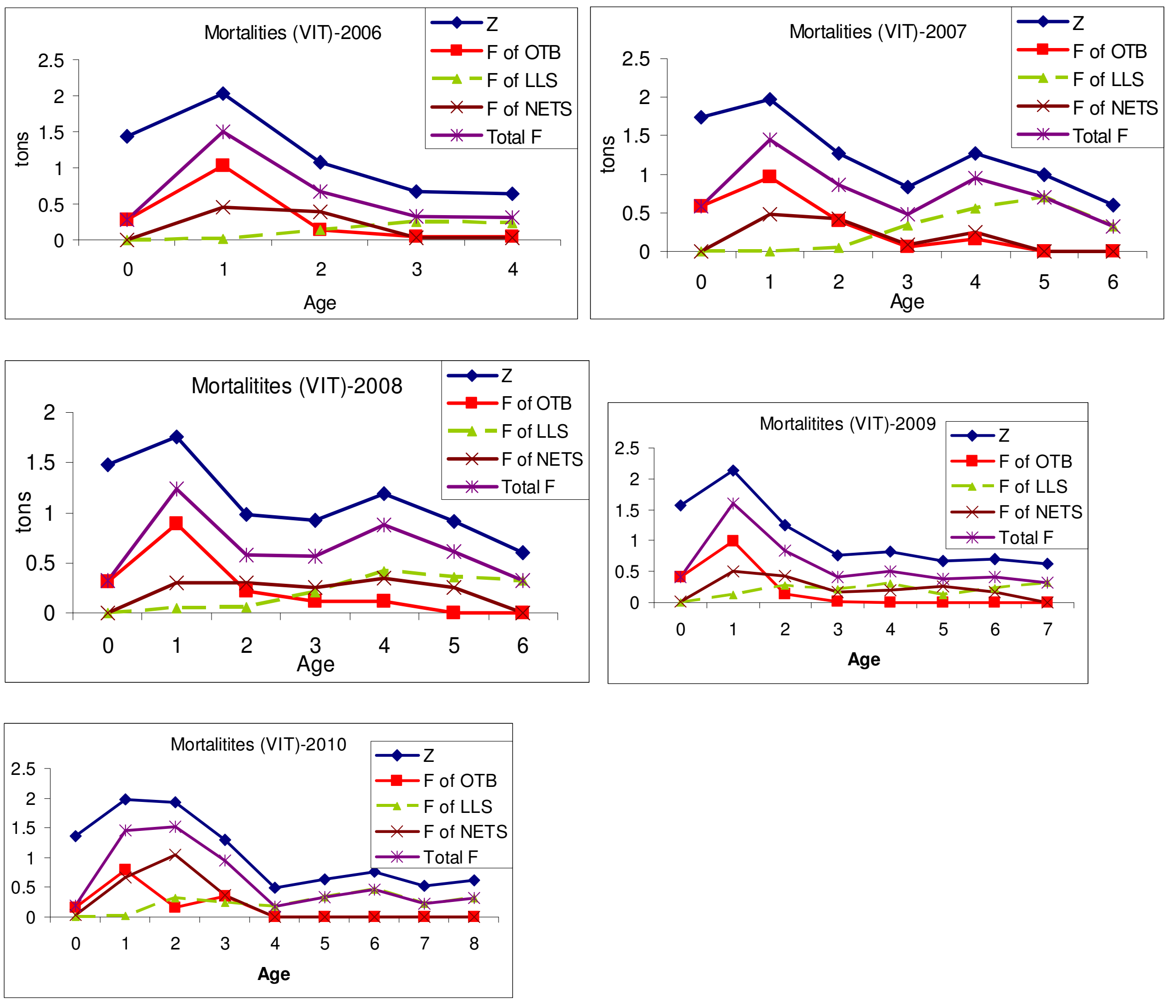


Fig. 6.1.4.2.3.3. Total and fishing mortality by age as estimated by the cohort analysis using VIT for each year. Fast growth scenario.

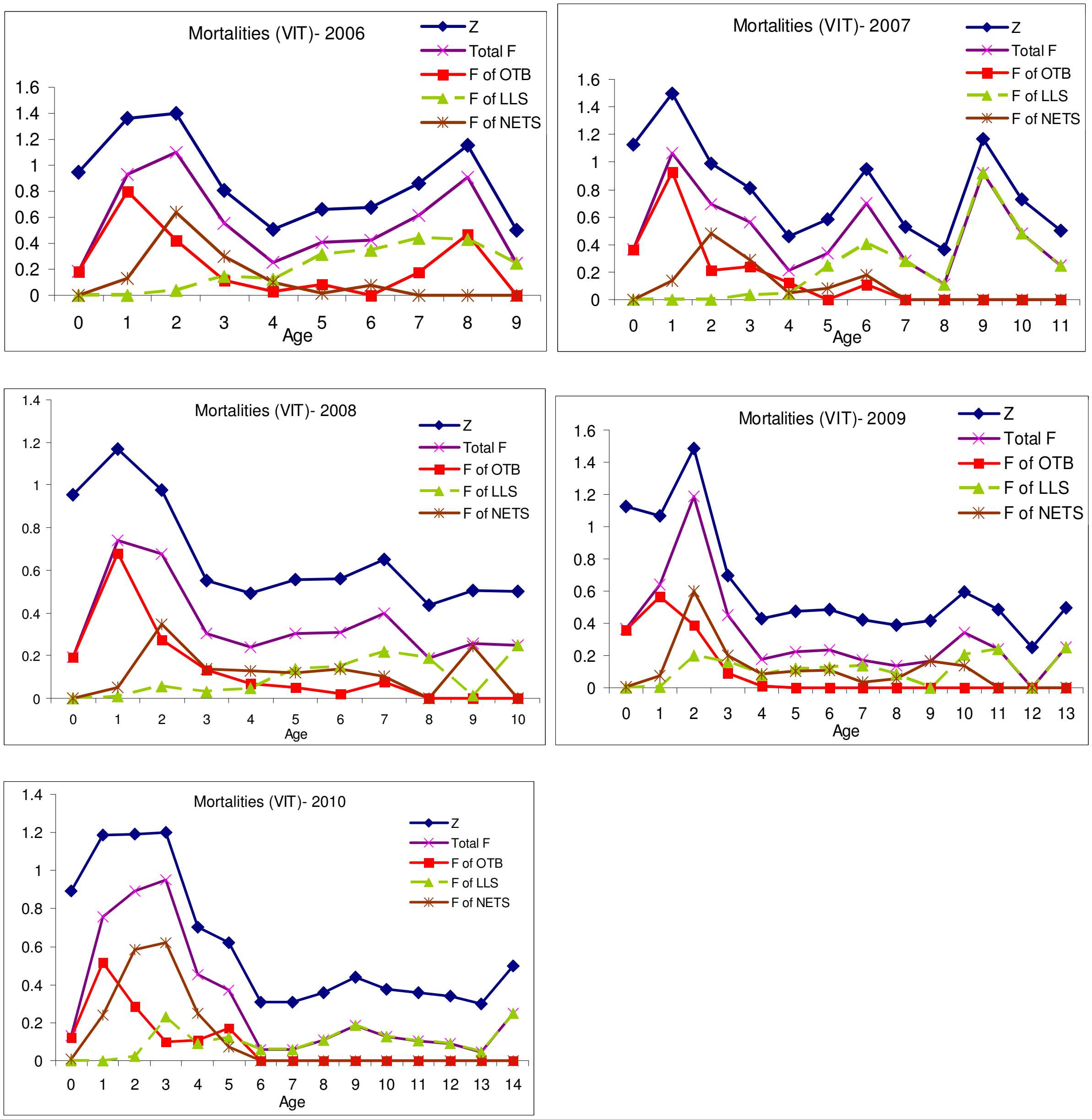
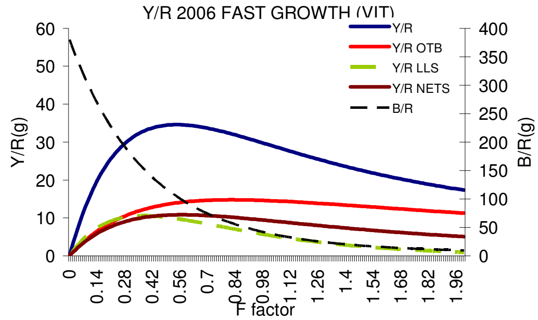
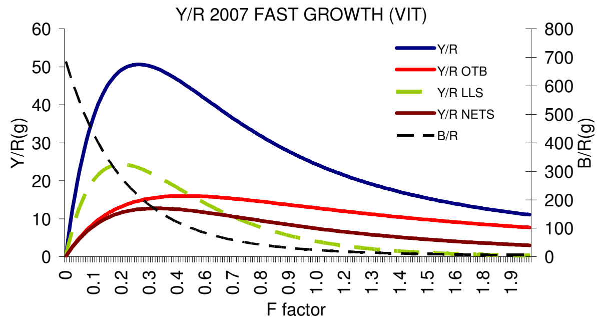


Fig. 6.1.4.2.3.4. Total and fishing mortality by age as estimated by the cohort analysis using VIT for each year. Slow growth scenario.

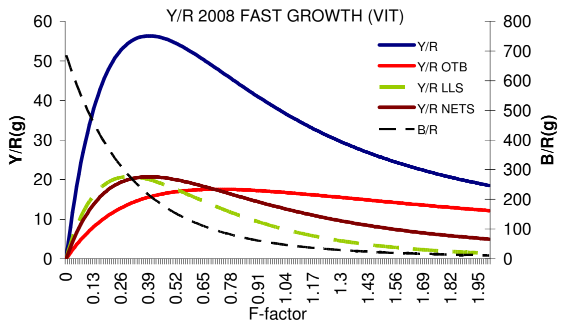
2006	Factor	F	Y/R	B/R	SSB	Y/R OTB	Y/R LLS	Y/R NETS
F(0)	0.00	0.00	0.00	379.84	336.71	0.00	0.00	0.00
F(0.1)	0.43	0.27	33.86	134.96	109.63	12.93	10.46	10.47
Fmax	0.55	0.34	34.58	105.12	82.72	13.95	9.83	10.80
Fcurr	1.01	0.62	29.45	40.42	26.27	14.58	5.54	9.33
Fdouble	2.00	1.24	17.31	9.65	2.85	11.25	0.99	5.07



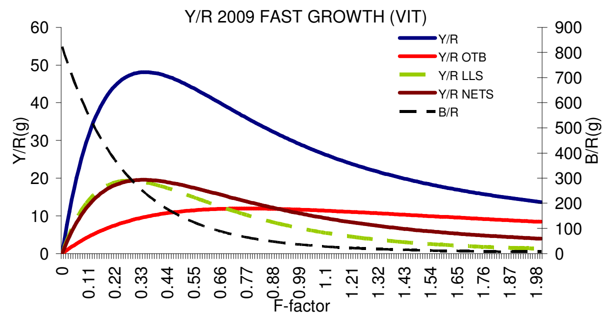
2007	Factor	F	Y/R	B/R	SSB	Y/R OTB	Y/R LLS	Y/R NETS
F(0)	0	0	0	685.605	642.474	0	0	0
F(0.1)	0.24	0.1838	49.182	277.52	247.868	13.231	24.32	11.63
Fmax	0.32	0.2451	50.641	216.478	189.755	14.671	23.501	12.469
Fcurr	1.01	0.766	26.564	28.611	17.783	13.415	5.047	8.102
Fdouble	2	1.532	11.032	5.387	1.3	7.7	0.312	3.02



2008	Factor	F	Y/R	B/R	SSB	Y/R OTB	Y/R LLS	Y/R NETS
F(0)	0.00	0.00	0.00	685.61	642.47	0.00	0.00	0.00
F(0.1)	0.30	0.19	54.76	277.01	246.31	13.88	20.76	20.12
Fmax	0.40	0.26	56.32	215.33	187.46	15.57	20.02	20.73
Fcurr	1.01	0.64	37.86	50.62	35.18	16.89	7.88	13.10
Fdouble	2.00	1.29	18.51	11.36	4.05	12.16	1.39	4.96



2009	Factor	F	Y/R	B/R	SSB	Y/R OTB	Y/R LLS	Y/R NETS
F(0)	0	0	0	822.776	779.645	0	0	0
F(0.1)	0.27	0.165	46.931	312.884	283.958	8.5	19.311	19.12
Fmax	0.36	0.22	48.131	238.121	212.228	9.758	18.843	19.53
Fcurr	1.01	0.611	28.795	35.27	23.362	11.633	6.623	10.539
Fdouble	2	1.222	13.658	6.727	1.599	8.423	1.295	3.94



2010	Factor	F	Y/R	B/R	SSB	Y/R OTB	Y/R LLS	Y/R NETS
F(0)	0	0	0	943.44	900.309	0	0	0
F(0.1)	0.26	0.16276	53.642	321.309	290.156	11.388	22.17	20.084
Fmax	0.35	0.2191	54.965	235.845	207.418	12.559	20.642	21.764
Fcurr	1.01	0.626	34.832	33.216	18.04	12.818	4.946	17.068
Fdouble	2	1.252	19.956	9.883	1.87	10.135	0.675	9.146

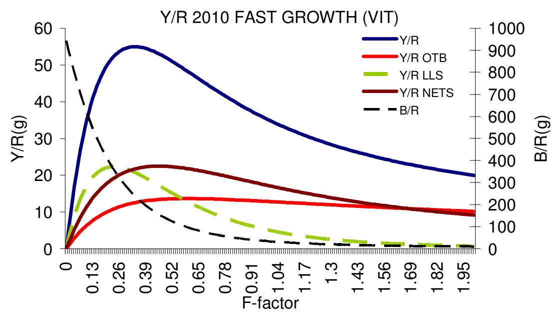
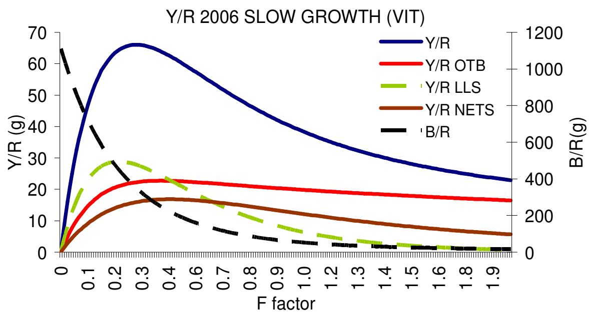
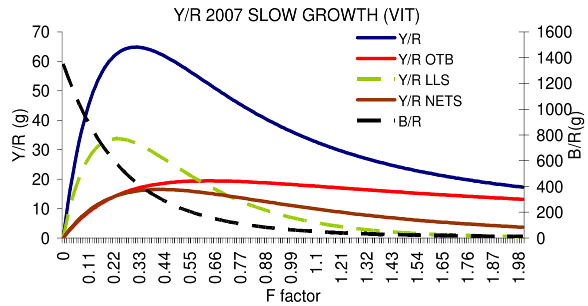


Fig. 6.1.4.2.3.5. Y/R curves by gear and year from VIT analysis. For each year the overall estimates regarding F-factor, F (F_0, $F_{0.1}$, F_{max}, F_{curr}, F_{double}), overall and by gear Y/R, B/R and SSB are reported. Fast growth scenario. B/R by year and F-factor is also showed.

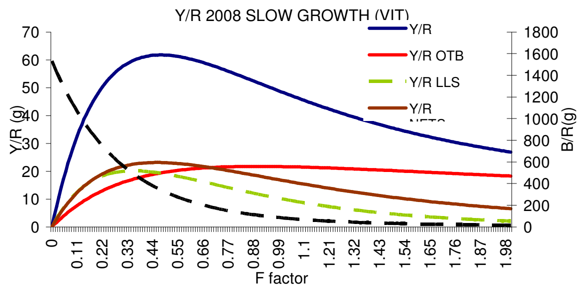
2006	Factor	F	Y/R	B/R	SSB	Y/R OTB	Y/R LLS	Y/R NETS
F(0)	0	0	0	1109.87	1033.73	0	0	0
F(0.1)	0.25	0.141	64.005	461.452	405.107	20.846	28.853	14.307
Fmax	0.34	0.19176	66.057	355.725	304.223	22.231	27.955	15.871
Fcurr	1.01	0.564	40.803	61.866	34.668	20.197	7.671	12.935
Fdouble	2	1.128	22.879	16.709	2.544	16.445	0.773	5.661



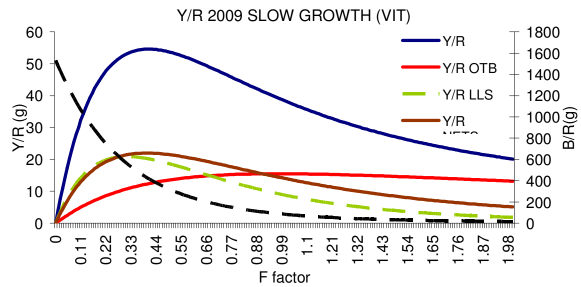
2007	Factor	F	Y/R	B/R	SSB	Y/R OTB	Y/R LLS	Y/R NETS
F(0)	0	0	0	1352.447	1276.312	0	0	0
F(0.1)	0.24	0.11952	62.956	561.351	506.46	14.693	33.707	14.555
Fmax	0.33	0.16434	64.812	427.043	377.574	16.821	32.036	15.955
Fcurr	1.01	0.498	35.914	62.644	39.952	18.137	6.824	10.954
Fdouble	2	0.996	17.257	12.509	2.644	13.14	0.432	3.685



2008	Factor	F	Y/R	B/R	SSB	Y/R OTB	Y/R LLS	Y/R NETS
F(0)	0	0	0	1239.158	1163.022	0	0	0
F(0.1)	0.36	0.12636	59.983	494.406	440.075	17.267	20.123	22.593
Fmax	0.49	0.17199	61.776	371.302	322.414	19.466	19.209	23.101
Fcurr	1.01	0.351	48.546	122.291	90.108	21.652	10.098	16.797
Fdouble	2	0.702	26.883	27.524	10.522	18.263	2.083	6.537



2009	Factor	F	Y/R	B/R	SSB	Y/R OTB	Y/R LLS	Y/R NETS
F(0)	0	0	0	1532.513	1456.377	0	0	0
F(0.1)	0.31	0.10168	53.121	563.601	510.791	10.747	20.907	21.467
Fmax	0.42	0.13776	54.623	414.771	367.446	12.481	20.14	22.002
Fcurr	1.01	0.328	38.433	84.374	57.688	15.527	8.84	14.066
Fdouble	2	0.656	20.103	16.488	3.818	13.182	1.827	5.094



2010	Factor	F	Y/R	B/R	SSB	Y/R OTB	Y/R LLS	Y/R NETS
F(0)	0	0	0	1601.65	1525.51	0	0	0
F(0.1)	0.33	0.10065	56.952	525.569	470.228	14.27	18.173	24.509
Fmax	0.45	0.13725	58.666	371.516	321.333	15.711	16.677	26.277
Fcurr	1.01	0.305	45.241	84.657	52.275	16.649	6.424	22.168
Fdouble	2	0.61	27.545	22.325	4.185	14.664	0.973	11.909

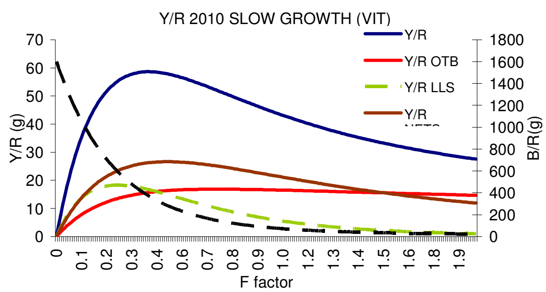


Fig. 6.1.4.2.3.6. Y/R curves by gear and year from VIT analysis. For each year the overall estimates regarding F-factor, F (F_0, $F_{0.1}$, F_{max}, F_{curr}, F_{double}), overall and by gear Y/R, B/R and SSB are reported. Slow growth scenario. B/R by year and F-factor is also showed.

6.1.5 *Data quality and availability*

Data from DCF 2011 were used. Assessments were performed for the new submitted time series. Comparisons with past assessments (SGMED 03-2010 report) evidence only little variations and consistent estimates. A consistent sum of products was observed (less than 10%).

6.1.6 Scientific advice

6.1.6.1 State of the spawning stock size

Survey indices indicate a variable pattern of abundance (n/h) and biomass (kg/h) without any trend. However, recent values are among the highest observed since 1994. The hind casting approach using Aladym model in SGMED 09-02 showed instead that the SSB was continuously decreasing (Figure 6.1.6.1.1).

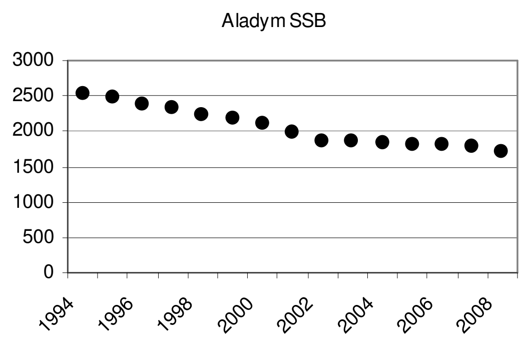


Fig. 6.1.6.1.1. Pattern of the spawning stock biomass as obtained through Aladym simulation in SGMED 02 2009.

No biomass reference points have been proposed for this stock. As a result, SGMED is unable to evaluate the status of the stock with respect to biomass.

6.1.6.2 State of recruitment

Recent recruitment since 2005 appears to be above average, as derived directly from the trawl survey estimates considering as recruits the age 0 group (Figure 6.1.6.2.1) and from the SURBA model analysis (Fig. 6.1.4.1.3.5) .

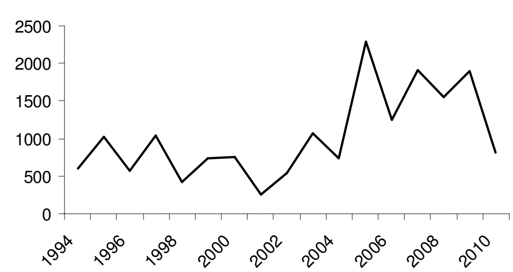


Fig. 6.1.6.2.1. Recruitment pattern from survey data.

6.1.6.3 State of exploitation

Analyses performed applying different approaches gave consistent results, indicating that the fishing mortality is far in excess of sustainable levels, and that the stock of *Merluccius merluccius* in the GSA10 appears to be subject to overfishing. EWG proposes $F_{0.1} \leq 0.17$ as limit management reference point. Regardless of the growth pattern, a considerable reduction, of about ~70%, would be necessary to approach $F_{0.1}$ reference point. EWG recommends the relevant fleet's effort to be reduced until fishing mortality is below or at $F_{0.1}$ (that is 0.63 in 2010) in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects.

6.2 Stock assessment of red mullet in GSA 10

6.2.1 Stock identification and biological features

6.2.1.1 Stock Identification

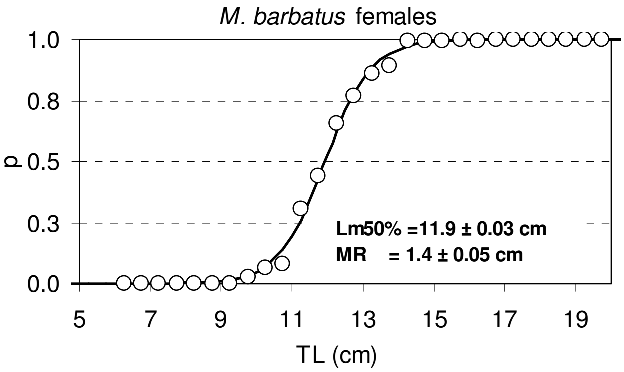
Red mullet stock was assumed in the boundaries of the whole GSA 10, lacking specific information on stock identification. *M. barbatus* is with European hake and deep-water rose shrimp a key species of the fishing assemblages in the central-southern Tyrrhenian Sea (GSA 10). The species is almost exclusively distributed on the continental shelf and is a rather small-sized, fast-growing and characterized by a relatively short lifespan. It spawns in late spring-early summer with a peak in June-July. In late summer, recently settled juveniles are highly concentrated nearshore and this concentration is still present until October. Aggregation of juveniles and subsequent movements towards more offshore grounds have been reported and indicated as a source of increased vulnerability of this population component to harvest (Voliani *et al*., 1998). During late summer-early autumn (September-October), the species is intensely fished. About three-four months after settlement, red mullet has spread up to depths of about 100 m.

6.2.1.2 Growth

The growth of red mullet has been studied in the GSA 10 using otolith readings and the analysis of length-frequency distributions using techniques as Batthacharya for separation of modal components. The estimates of the von Bertalanffy growth parameters by sex for the period 2006-2009 were: females L_∞=27 cm k=0.363 t_0= -0.6; males: L_∞=21 cm k=0.534 t_0= -0.5; sex combined L_∞=30 cm k=0.38 t_0= -0.35. Parameters of the length-weight relationship were a=0.0105; b=3.0207 for females, a=0.0103; b=3.0231 for males and a=0.0103; b=3.0246 for sex combined.

6.2.1.3 Maturity

According to the data obtained in the DCF, the proportion of mature females (fish belonging to the maturity stage 2b onwards macroscopically classified using a 8 stage scale (Medits-Handbook_2007.v5) by length class in the period 2006-2008 is reported in the table below together with the estimated maturity ogives which indicates a $L_{m50\%}$ of about 12 cm (±0.03 cm) (Figure 6.2.1.3.1).



TL (cm)	Proportion of mature females
9	0.017
10	0.075
11	0.38
12	0.71
13	0.88
14	0.99
15	0.99
16	0.99
17	1
18	1
19	1
20	1

Fig. 6.2.1.3.1. Maturity ogives and proportions of mature female of red mullet in the GSA 10 (MR indicates the difference $Lm_{75\%}$-$Lm_{25\%}$).

The sex ratio was in favour of males up to the size of about 11 cm and females start to prevail for large individuals (Fig. 6.2.1.3.2).

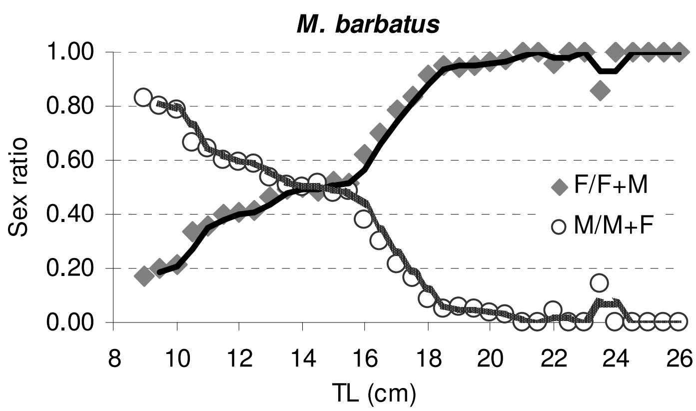


Fig. 6.2.1.3.2. Sex ratio for females and males by length.

6.2.2 Fisheries

6.2.2.1 General description of fisheries

Red mullet is an important species in the area, targeted by trawlers and small scale fisheries using mainly gillnet and trammel nets. Fishing grounds are located along the coasts of the whole GSA within the continental shelves.

6.2.2.2 Management regulations applicable in 2009 and 2010

Management regulations are based on technical measures, closed number of fishing licenses for the fleet and area limitation (distance from the coast and depth). In order to limit the over-capacity of fishing fleet, the Italian fishing licenses have been fixed since the late eighties. Other measures on which the management regulations are based regard technical measures (mesh size) and minimum landing sizes (EC 1967/06).

After 2000, in agreement with the European Common Policy of Fisheries, a gradual decreasing of the fleet capacity is implemented. Along northern Sicily coasts two main Gulfs (Patti and Castellammare) have been closed to the trawl fishery up 200 m depth, since 1990.

In the GSA 10 the fishing ban has not been mandatory along the time, and from one year to the other it was adopted on a voluntary basis by fishers, whilst in the last years it was mandatory. Regarding long-lines the management regulations are based on technical measures related to the number of hooks and the minimum landing sizes (EC 1967/06), besides the regulated number of fishing licences.

In 2008 a management plan was adopted, that foresaw the reduction of fleet capacity associated with a reduction of the time at sea. Two biological conservation zone (ZTB) were permanently established in 2009 (Decree of Ministry of Agriculture, Food and Forestry Policy of 22.01.2009; GU n. 37 of 14.02.2009). One is located along the mainland, in front of Sorrento peninsula in the vicinity of the MPA of Punta Campanella (Napoli Gulf, 60 km^2, within 200 m depth)) and a second one is along the coasts of Amantea (Calabrian coasts, 75 km^2 up to 250 m depth)). In these areas trawling is forbidden and other fishing activities are allowed under permission. Since June 2010 the rules implemented in the EU regulation (EC 1967/06) regarding the cod-end mesh size and the operative distance of fishing from the coasts are enforced.

6.2.2.3 Catches

6.2.2.3.1 Landings

Available landing data collected under the DCF framework ranged from 513 tons in 2004 to 176 tons in 2010, the latter being the lowest value registered (Table 6.2.2.3.1.1 and Figure 6.2.2.3.1.1). Most part of the landings of red mullet were from trawlers up to 2006 (Figure 6.2.2.3.1.1), while since 2007 the level of catches of trawlers is similar to that of the other métier grouped together, to which the maximum contribution is given by gillnet (GNS) and trammel net (GTR). Since 2008 the catches of both métier are decreasing.

Table 6.2.2.3.1.1. Annual landings by major fishing techniques in tons for red mullet in the GSA 10 (2004-2010).

Area	Species	Gear	Fishery	2004	2005	2006	2007	2008	2009	2010
10	MUT	GNS	DEMF	16	25	35	24	7	7	15
10	MUT	GTR	DEMSP	96	102	68	212	133	98	26
10	MUT	OTB	DWSP			1	0	0	0	
10	MUT	OTB	DEMSP	184		19	43	146	122	92
10	MUT	OTB	MDDWSP	217	255	269	222	36	51	43

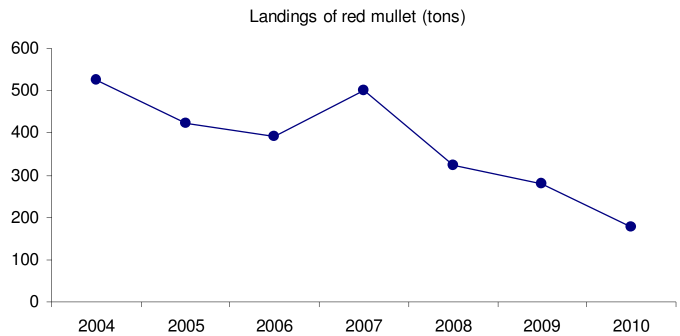


Fig. 6.2.2.3.1.1. Annual landings by major fishing techniques in tons for red mullet in the GSA 10 (2004-2010).

6.2.2.3.2 Discards

The proportion of the discards of red mullet in the GSA 10 was generally low (less than 10%) and mainly related to the third and fourth quarter. Discards data of 2006, 2009 and 2010 were available, but considering the amount and the fact that the collection of discard data was not foreseen in DCF in 2007 and 2008 these data were not used in the analyses.

6.2.2.3.3 Fishing effort

The trends in fishing effort by year and major gear type in terms of kWdays are listed in Table 6.2.2.3.3.1.

Table 6.2.2.3.3.1. Trend in nominal effort (kW*days) for GSA 10 by gear type, 2004-2010 as reported through the DCF official data call.

Area	Gear	Fishery	2004	2005	2006	2007	2008	2009	2010	Total
SA 10			5212242	3873979	3255356	2531896	1924958	2018775	1426305	20243511
		CEP	599410	425518	412143	342733	788684	1114012	613164	4295664
		DEMSP	704007	202984	114568	33279	123312	23990	171509	1373649
		FINF	1696	3455	1767	18469			1928	27315
	DRB	MOL	86117	294424	312180	144186	241664	188909	206550	1474030
	FPO	DEMSP	0	312076	148868					460944
	GND	SPF	281464	128070	622561	442465	470435	440882	103959	2489836
	GNS	DEMSP	4047979	5028180	2953928	2052278	2467212	2544508	2520971	21615056
		SLPF	1556			94137	1910	30214	12173	139990
	GTR	DEMSP	3374829	1739878	4295352	3854825	3105046	2480175	2522528	21372633
	LLD	LPF	1044137	1135956	791936	404235	353211	1287002	1660409	6676886
	LLS	DEMF	4563483	1810269	1434965	1194701	1316931	885225	973619	12179193
	LTL	LPF	0							0
	OTB	DEMSP	3648016	72338	1491604	1528297	3743680	3482911	3576824	17543670
		DWSP			246152	82495	116434	239720	289440	974241
		MDDWSP	4422360	7956395	5762828	5676419	2382266	2563895	1809087	30573250
	PS	LPF	1254287	807500	96501	186494	243450	1076308	475177	4139717
		SPF	3330804	2173517	1844148	1807146	973629	1623539	1075689	12828472
	PTB	SPF	6173							6173

6.2.3 Scientific surveys

6.2.3.1 Medits

6.2.3.1.1 Methods

According to the MEDITS protocol (Bertrand *et al*., 2002), trawl surveys were carried out yearly (May-July), applying a random stratified sampling by depth (5 strata with depth limits at: 50, 100, 200, 500 and 800 m; each haul position randomly selected in small sub-areas and maintained fixed throughout the time). Haul allocation was proportional to the stratum area. The same gear (GOC 73, by P.Y. Dremière, IFREMER-Sète), with a 20 mm stretched mesh size in the cod-end, was employed throughout the years. Detailed data on the gear characteristics, operational parameters and performance are reported in Dremière and Fiorentini (1996). Considering the small mesh size a complete retention was assumed. Abundance data (number of fish per surface unit) were standardised to square kilometre, using the swept area method.

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 10 the following number of hauls were reported per depth stratum (Table 6.2.3.1.1.1).

Table 6.2.3.1.1.1. Number of hauls per year and depth stratum in GSA 10, 1994-2010.

GSA 10	Year																
Stratum	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
10-50 m	7	8	8	8	8	8	8	8	6	7	7	7	7	7	7	7	7
50-100 m	10	10	10	10	10	10	10	10	9	8	8	8	8	8	8	8	8
100-200 m	17	17	17	17	17	17	17	17	14	14	14	14	14	14	14	14	14
200-500 m	22	22	22	22	22	22	22	24	18	18	18	18	18	18	19	18	18
500-800 m	28	28	28	28	28	27	28	26	23	23	23	23	23	23	22	23	23
Total	84	85	85	85	85	84	85	85	70	70	70	70	70	70	70	70	70

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma\ (Yi*Ai) / A$$

$$V(Yst) = \Sigma\ (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area

Ai=area of the i-th stratum

si=standard deviation of the i-th stratum

ni=number of valid hauls of the i-th stratum

n=number of hauls in the GSA

Yi=mean of the i-th stratum

Yst=stratified mean abundance

V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien *et al*. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

6.2.3.1.2 Geographical distribution patterns

Map of the bubble plot of the survey indices indicates a higher abundance of the population in the southernmost part of the area, along the mainland and the north Sicily coasts. The approach based on spatial indicators (Woillez *et al*., 2007) to characterise the spatial dynamics of red mullet life stages has been applied to the GSA 10 (Spedicato *et al*., 2007), with the objectives of identifying areas where red mullet recruits are more concentrated (Figure 6.2.3.1.2.1), establishing relationships with the adult distribution and detecting the ability of spatial indicators to capture the stability of the spatial occupation of preferential sites across the years. The spatial indices mainly studied were the centre of gravity (CG), the inertia (I) and the global index of collocation (GIC). Gravity centres (xcg-longitude; ycg-latitude; graph below) by age groups across years and life-stages highlighted a less changing spatial location of the younger age (A1) compared to the older ones (A2 and A3) that were more dispersed. The approach of the spatial indicators enabled the location of the geographical zone (along the Calabrian coast, southwards in the study area) where recruits (age 0 fish) of red mullet are mainly distributed and to verify that these locations are rather stable across years.

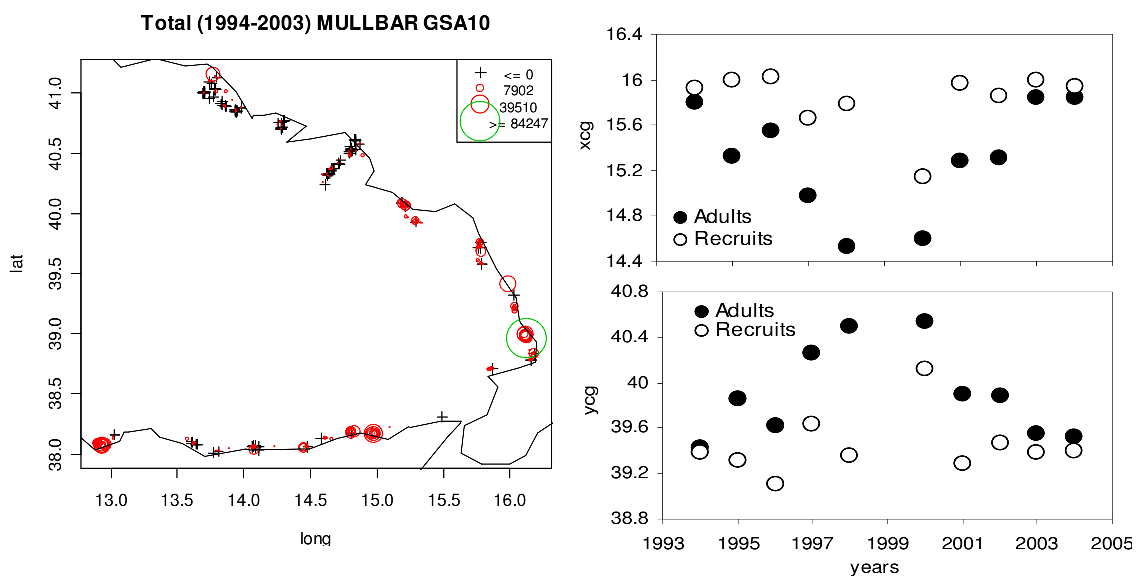


Fig. 6.2.3.1.2.1. Scaled survey catches of red mullet in GSA 10 and centre of gravity (CG) of recruits and adults.

6.2.3.1.3 Trends in abundance and biomass

Fishery independent information regarding the state of the red mullet in GSA 10 was derived from the international survey MEDITS. Figure 6.2.3.1.3.1 displays the estimated trend in red mullet abundance and biomass in GSA 10. Abundance indices from MEDITS trawl-survey show a very variable pattern also due to the intercepting of recruits in some years. However, the abundance and biomass showed a very variable pattern with a decreasing trend (-0.664 of Spearman rho) along the time series (increasing from 1999 to 2002, decreasing from 2000 to 2006 and again an increasing in 2007, followed by a sharp reduction in 2008, a new remarkable rising in 2009 and another decrease in 2010) (Figure 6.2.3.1.3.1).

The re-estimated abundance and biomass indices do reveal identical trends (Figure 6.2.3.1.3.2) to those shown above. However, the recent abundance and biomass indices in 2007 appear high but are subject to high uncertainty.

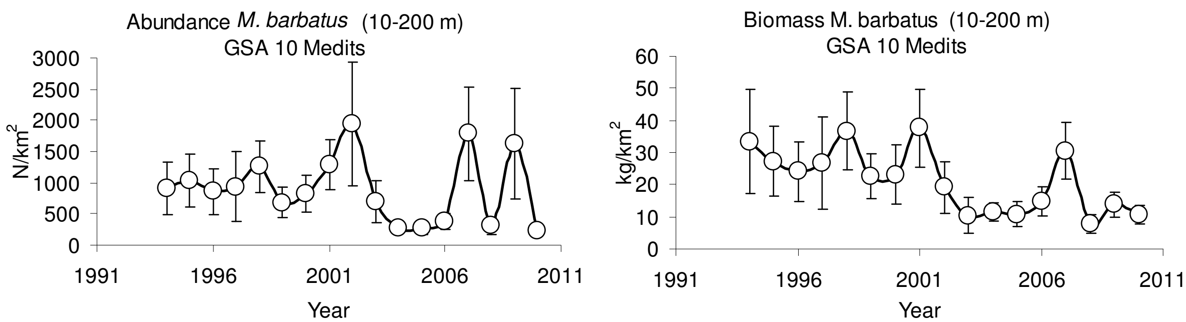


Fig. 6.2.3.1.3.1. Trends in survey abundance and biomass derived from MEDITS.

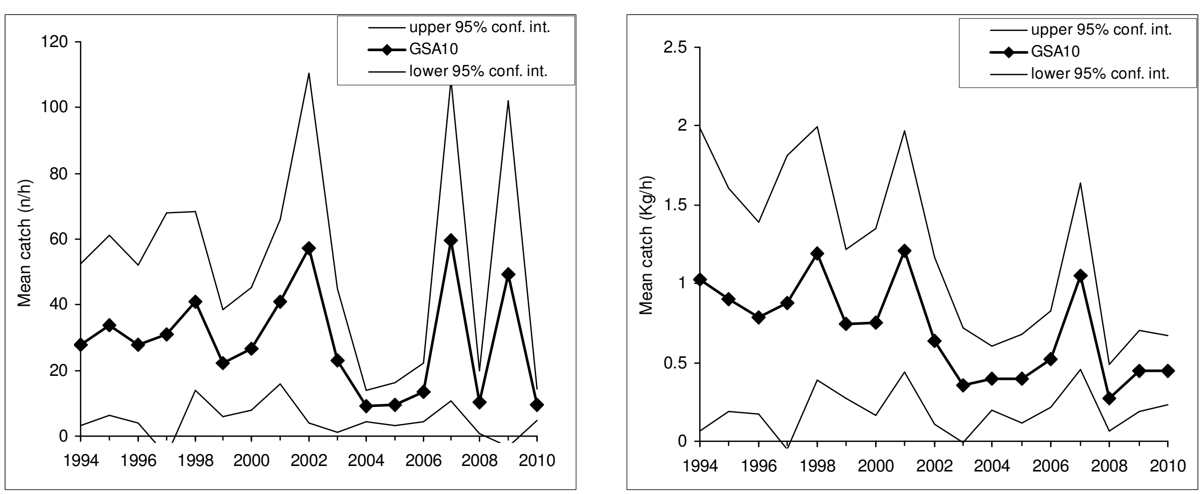


Fig. 6.2.3.1.3.2. Abundance and biomass indices of red mullet in GSA 10 derived from MEDITS.

6.2.3.1.4 Trends in abundance by length or age

No trend in the mean length was observed in MEDITS survey.

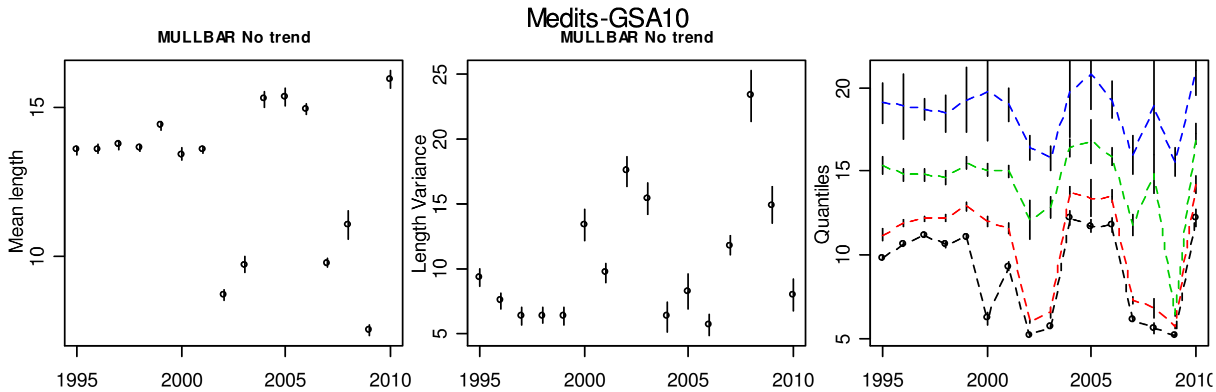


Fig. 6.2.3.1.4.1. Mean length, variance and quantiles derived from the MEDITS length compositions.

Figures 6.2.3.1.4.2 and 3 display the stratified abundance indices by length of red mullet in the GSA 10 in 1994-2001 and 2002-2010.

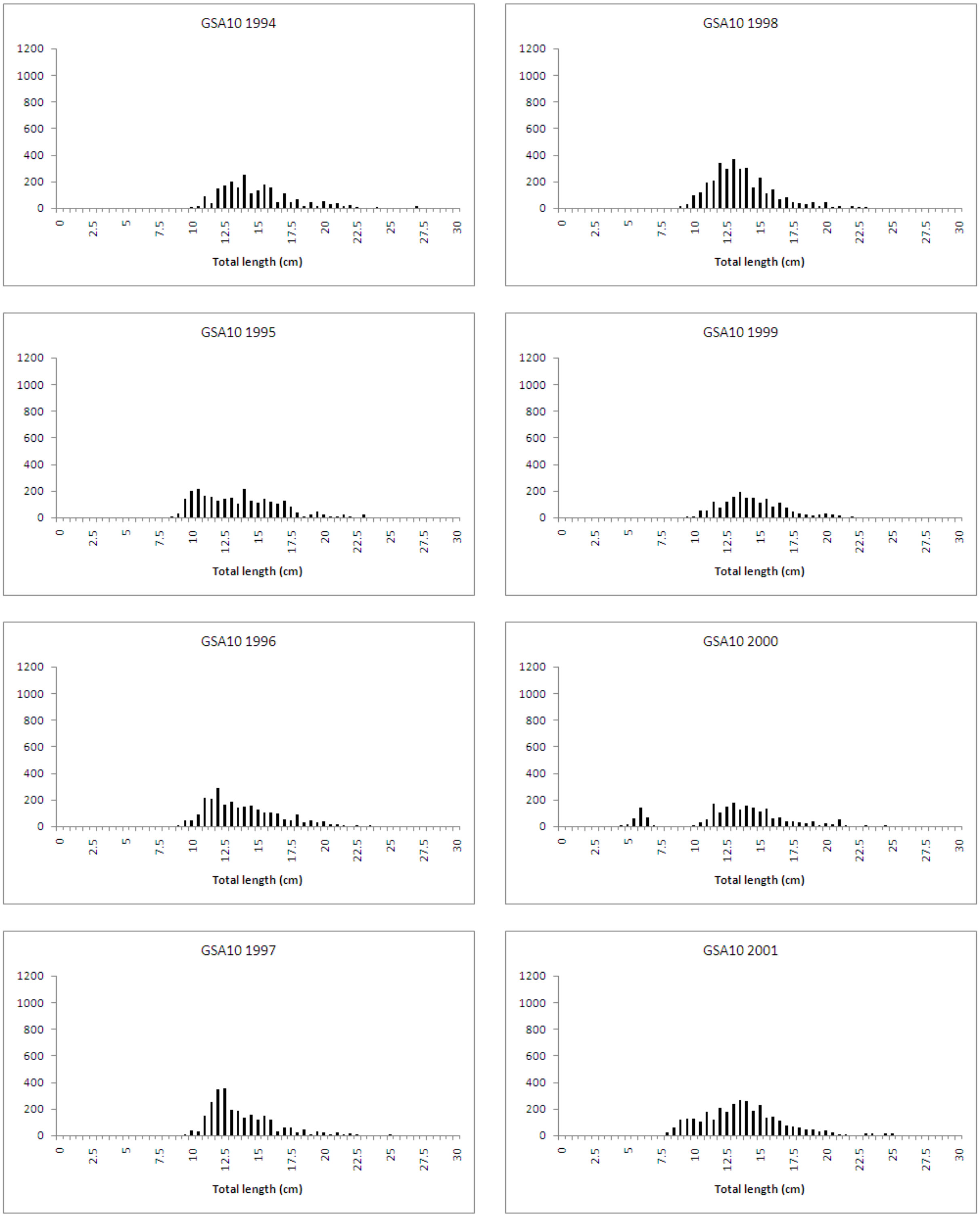
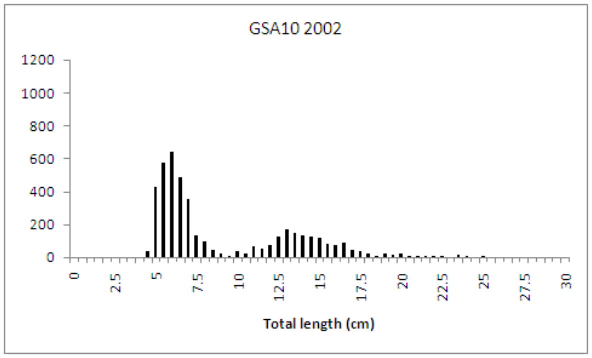
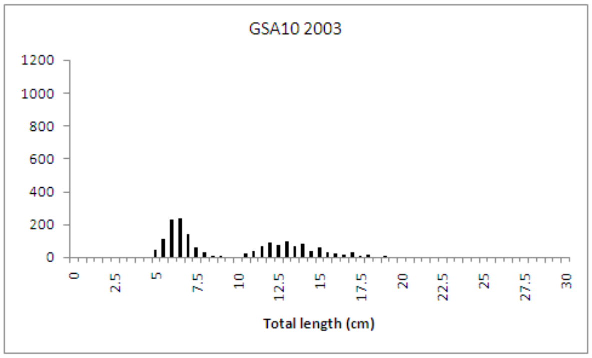
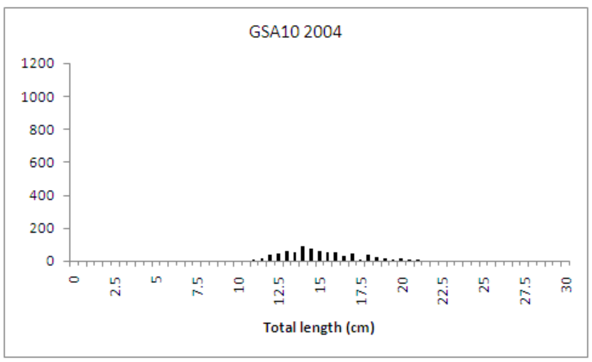
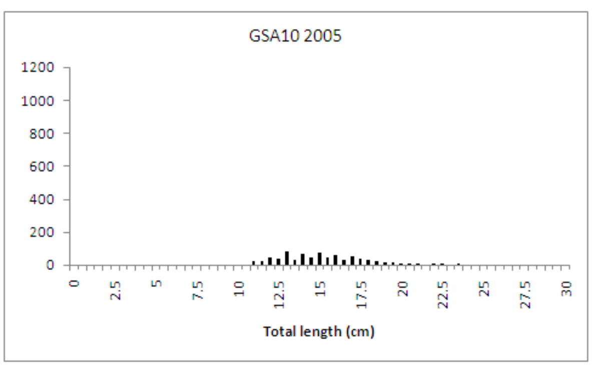


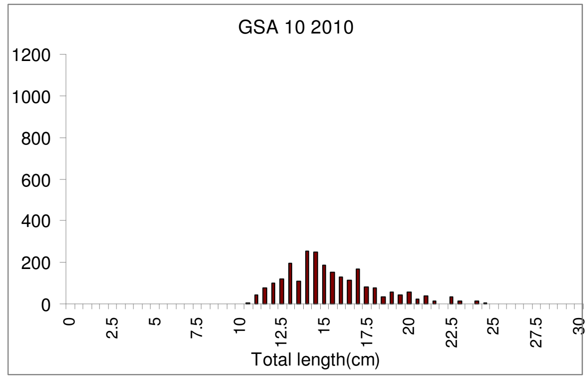
Fig. 6.2.3.1.4.2. Stratified abundance indices by size, 1994-2001.

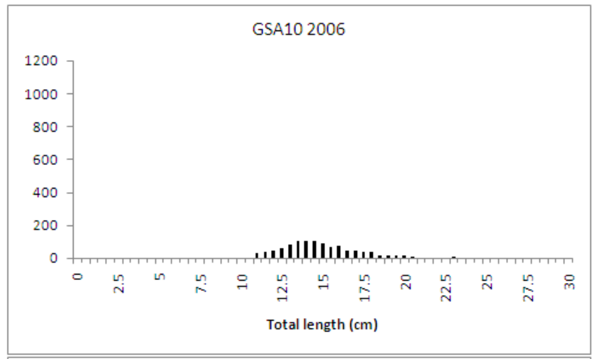

GSA10 2002
1200 1000 800 600 400 200 0
0 2.5 5 7.5 10 12.5 15 17.5 20 22.5 25 27.5 30
Total length (cm)

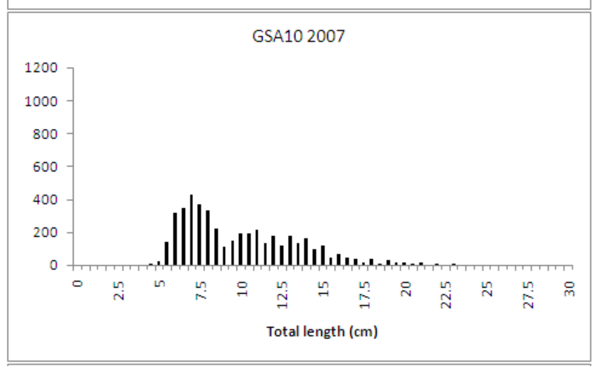

GSA10 2003
1200 1000 800 600 400 200 0
0 2.5 5 7.5 10 12.5 15 17.5 20 22.5 25 27.5 30
Total length (cm)

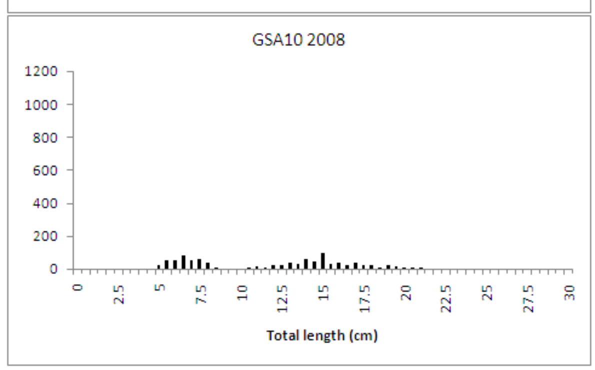

GSA10 2004
1200 1000 800 600 400 200 0
0 2.5 5 7.5 10 12.5 15 17.5 20 22.5 25 27.5 30
Total length (cm)


GSA10 2005
1200 1000 800 600 400 200 0
0 2.5 5 7.5 10 12.5 15 17.5 20 22.5 25 27.5 30
Total length (cm)


GSA 10 2010
1200 1000 800 600 400 200 0
0 2.5 5 7.5 10 12.5 15 17.5 20 22.5 25 27.5 30
Total length(cm)


GSA10 2006
1200 1000 800 600 400 200 0
0 2.5 5 7.5 10 12.5 15 17.5 20 22.5 25 27.5 30
Total length (cm)


GSA10 2007
1200 1000 800 600 400 200 0
0 2.5 5 7.5 10 12.5 15 17.5 20 22.5 25 27.5 30
Total length (cm)


GSA10 2008
1200 1000 800 600 400 200 0
0 2.5 5 7.5 10 12.5 15 17.5 20 22.5 25 27.5 30
Total length (cm)

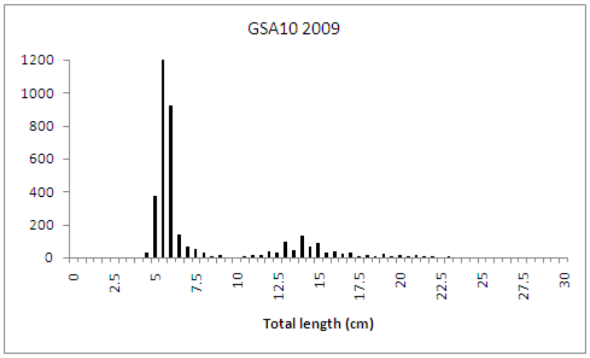


Fig. 6.2.3.1.4.3. Stratified abundance indices by size, 2002-2010.

6.2.3.2 Grund

6.2.3.2.1 Methods

Since 2003 GRUND surveys (Relini, 2000) was conducted using the same sampler (vessel and gear) in the whole GSA. Sampling scheme, stratification and protocols were similar as in MEDITS. All the abundance data (number of fish and weight per surface unit) were standardised to km^2 using the swept area method.

6.2.3.2.2 Geographical distribution patterns

Map of abundance of recruits ($n \cdot km^{-2}$) as estimated using GRUND data and the ordinary kriging shows that the sub-zones where the recruits are mainly concentrated along the nearshore grounds of the southernmost part of the GSA, except a nucleus located in the northernmost side (Figure 6.2.3.2.2.1). The higher values were around 25000 recruits$\cdot km^{-2}$. On average, considering the analyzed distributions (years 1994-2005), the recruits are individual smaller than 11.5 cm (±1.08). These individual are mostly belonging to the age 0+ group.

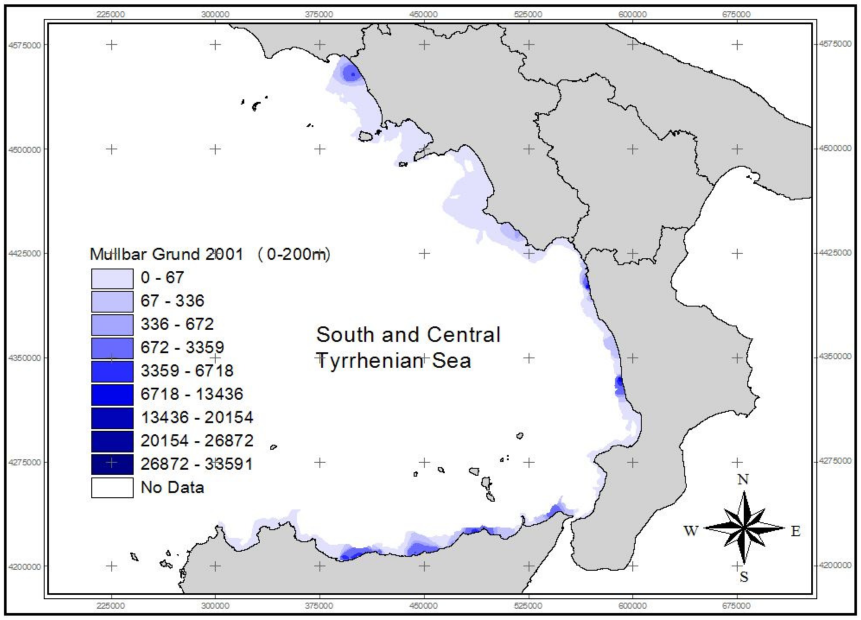


Fig. 6.2.3.2.2.1. Map of abundance of recruits (n·km^{-2}) as estimated using GRUND data and the ordinary kriging.

6.2.3.2.3 Trends in abundance and biomass

Similar to MEDITS trends are derived from the GRUND survey and shown in Fig. 6.2.3.2.3.1. Biomass and abundance indices were both decreasing, while the recruitment indices were highly variable but without any significant trend. Low levels were however observed in the periods 1994-1996 and 2003-2008.

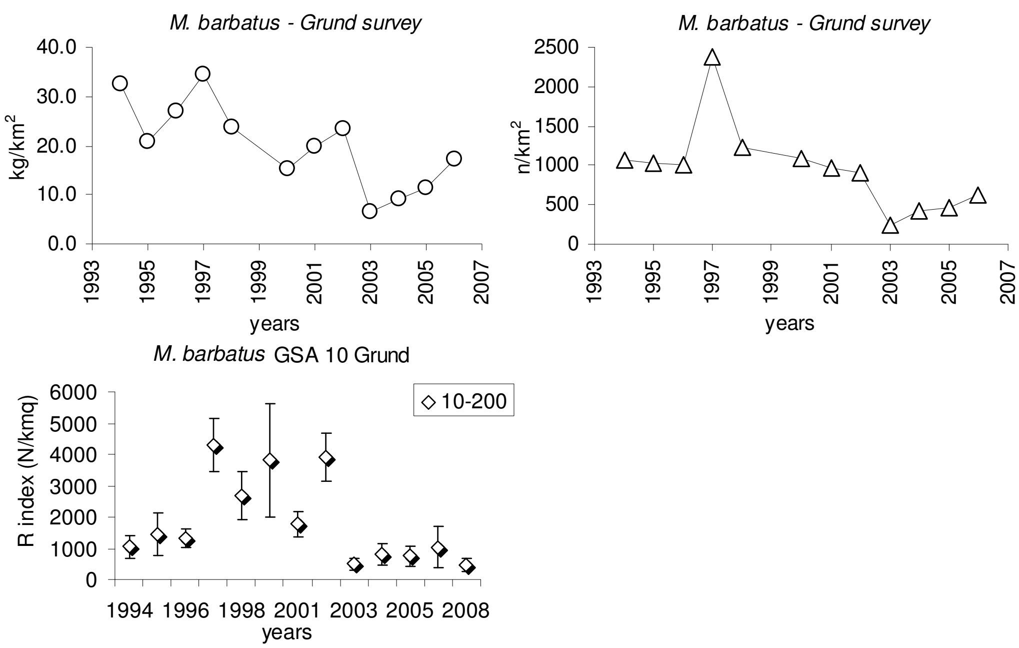


Fig. 6.2.3.2.3.1. Abundance and biomass indices of red mullet in GSA 10 derived from GRUND survey. Also recruitment indices (n·km^{-2}) with standard deviation are reported.

6.2.3.2.4 Trends in abundance by length or age

No analyses presented during EWG 11-20.

6.2.3.2.5 Trends in growth

The occurrence of growth change along time was not fully explored during EWG 11-20.

6.2.3.2.6 Trends in maturity

No analyses were conducted during EWG 11-20.

6.2.4 Assessment of historic stock parameters

6.2.4.1 Method 1: VIT

6.2.4.1.1 Justification

Five years (2006-2010) of length frequency distributions of the landings were available. An approach under steady state (pseudocohort) assumption was applied to the data. Cohort (VPA equation) and Y/R analyses as implemented in the package VIT4win were used (Lleonart and Salat, 1997). Data of number at age were derived from DCF official data of August 2011 call.

6.2.4.1.2 Input parameters

A sex combined analysis was carried out. Regarding growth parameters the set L_∞=26 cm k=0.42 t_0= -0.4 was re-parameterized to the following equivalent set: L_∞=30 cm k=0.4 t_0= -0.4, to take into account the presence of individuals with length higher than 26 cm The length-weight relationship parameters were: a=0.0103; b=3.0246. A constant natural mortality M = 0.61 (Alagaraja, 1984) was adopted. This value was close to 0.7 an estimate reported for a very slightly exploited area in the Castellammare Gulf (northern Sicily coasts). The terminal fishing mortality was thus set at: F_{term}= 0.7. The setting of the proportion of mature females was 0.16 at age 0, 0.92 at age 1 and 1 at age 2. These values were derived from the proportion at length and the VBGF.

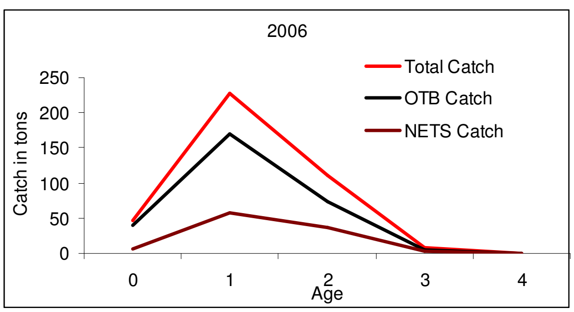
Table 6.2.4.1.2.1. Age distribution of landing from 2006 to 2010 used for VIT analysis.

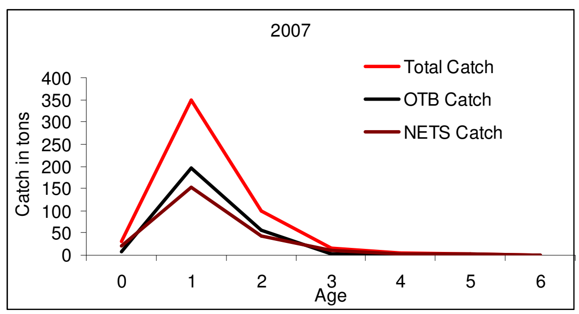
Age	2006		2007		2008		2009		2010	
	OTB	NETS	OTB	NETS	OTB	NETS	OTB	NETS	OTB	NETS
0	6,148,827	940,732	1,127,444	3,059,845	2,907,025	1,127,645	2,365,988	3,740,614	1,695,571	849,097
1	4,758,704	1,551,710	5,071,053	4,275,516	3,864,716	1,580,260	2,931,907	1,542,512	2,991,914	618,899
2	901,208	426,481	582,880	498,900	234,981	781,529	561,743	61,851	156,756	85,450
3	33,321	19,365	21,077	74,909	14,317	40,625	37,434	8,000	3,966	14,581
4	3,086	0	5,269	14,247	1,550	0	7,447	3,785	0	4,014
5			0	9,065					0	1,027
6			0	3,341						

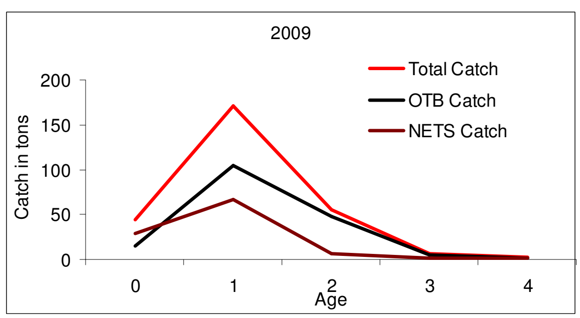
6.2.4.1.3 Results

The figure 6.2.4.1.3.1 shows the pattern of catch at age by year and fishing gear. The pattern of the reconstructed age class catch in weight is rather variable among the years, however the age 1 and 2 are the more abundant. Total mortality rate Z, total fishing mortality F, fishing mortality by fishing gear (OTB and Nets), as estimated by LCA using VIT are reported in the figure 6.2.4.1.3.2. Furthermore, the pattern of the fishing mortality by fishing fleet is rather variable among years and fishing mortality rates from the set nets is higher on the older age classes in 2006, 2008 and 2010 compared with 2007 and 2009.

The results for the cohort analysis show a current fishing mortality changing from 1.3 in 2006 to 0.76 in 2007, and on average around 1. In 2010 F was 1.01.







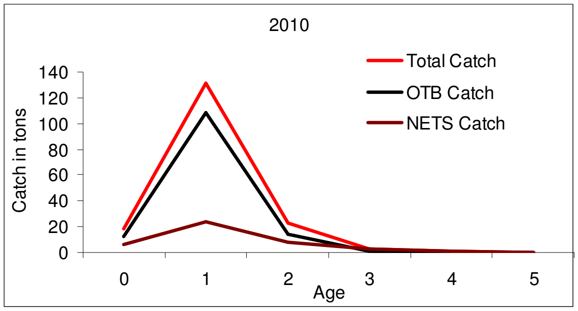


Fig. 6.2.4.1.3.1. Pattern of catch at age per year and fishing gear as estimated by the cohort analysis.

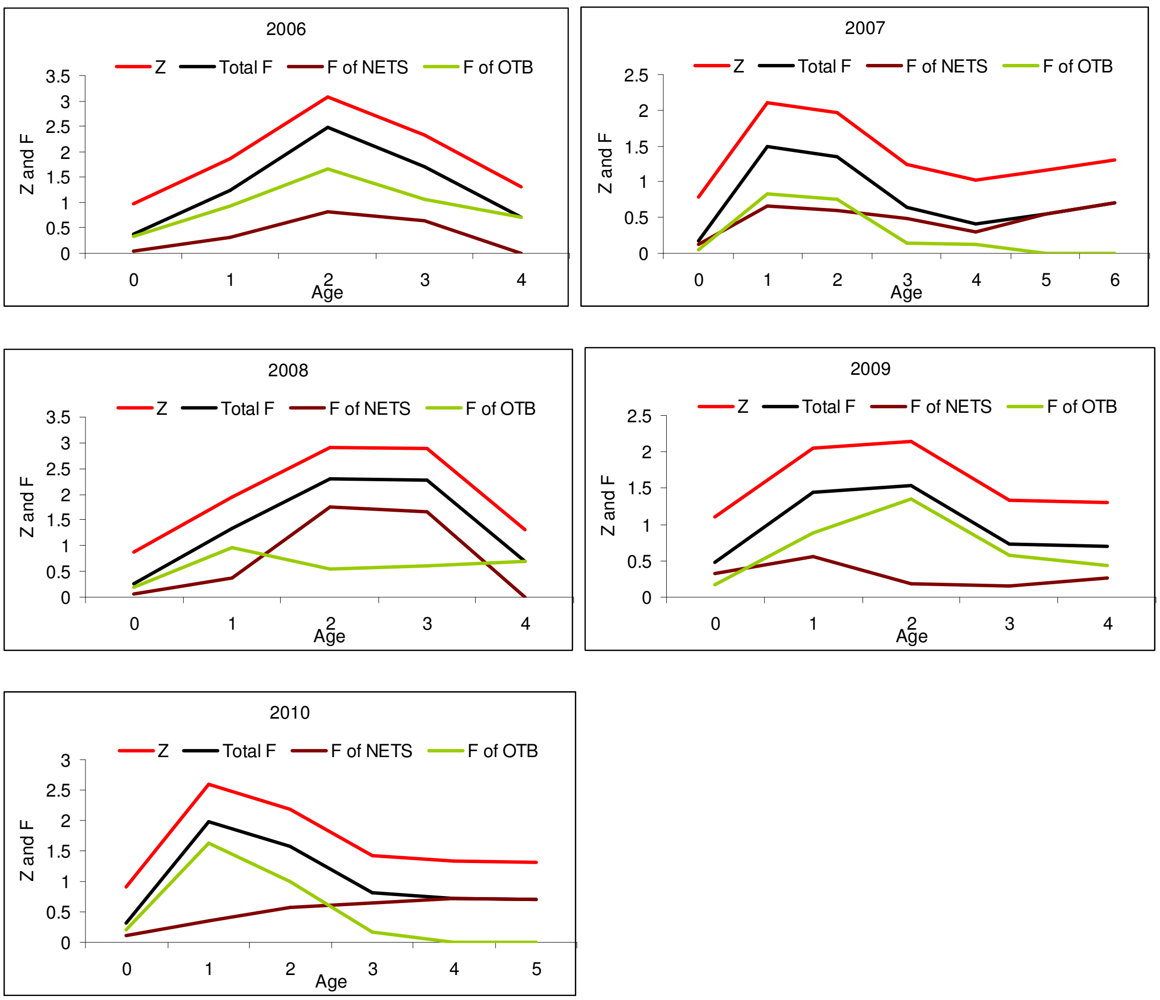


Fig. 6.2.4.1.3.2. Total and fishing mortality by age and gear as estimated by the cohort analysis.

6.2.5 Long term prediction

6.2.5.1 Justification

Yield per recruit analysis has been conducted by means of the VIT4win program.

6.2.5.2 Input parameters

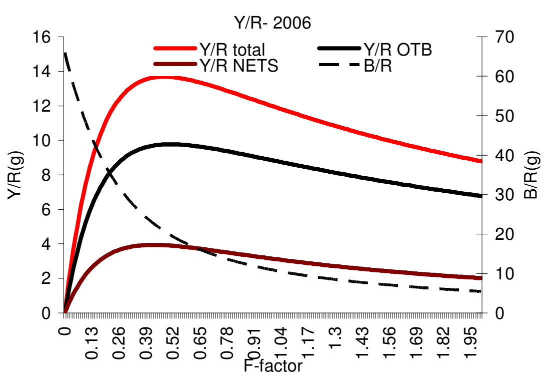
The same input parameters used for VPA for performing the Y/R analysis have been used.

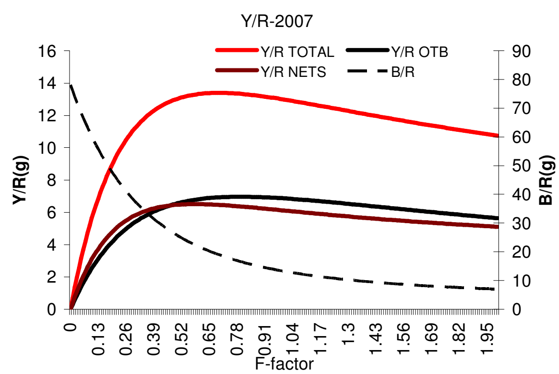
6.2.5.3 Results

The yield curves were slightly dome-shaped in 2007. The value of $F_{0.1}$ ranged between 0.36 in 2007 to 0.44 in 2008. $F_{0.1}$ among years 2008, 2009 and 2010 was on average 0.388.

2006	Factor	F	Y/R	B/R	SSB	Y/R OTB	Y/R NETS
F(0)	0	0	0	66.012	60.724	0	0
F(0.1)	0.33	0.429	13.18	27.318	22.701	9.321	3.858
Fmax	0.49	0.637	13.685	20.651	16.291	9.763	3.922
Fcurr	1.01	1.3	11.974	10.879	7.243	8.837	3.137
Fdouble	2	2.6	8.791	5.469	2.772	6.775	2.016

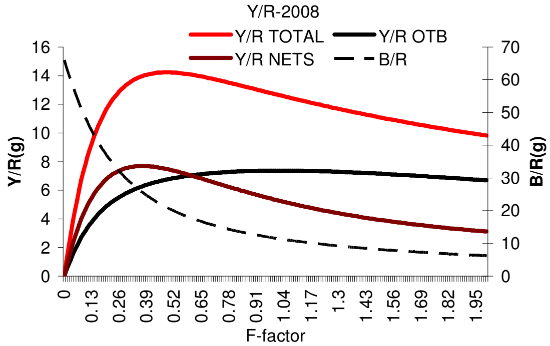
2007	Factor	F	Y/R	B/R	SSB	Y/R OTB	Y/R NETS
F(0)	0	0	0	78.113	72.826	0	0
F(0.1)	0.47	0.35861	12.879	27.104	22.475	6.445	6.434
Fmax	0.7	0.5341	13.397	19.11	14.719	6.93	6.467
Fcurr	1.01	0.763	12.983	13.241	9.132	6.868	6.115
Fdouble	2	1.526	10.75	6.994	3.543	5.639	5.111

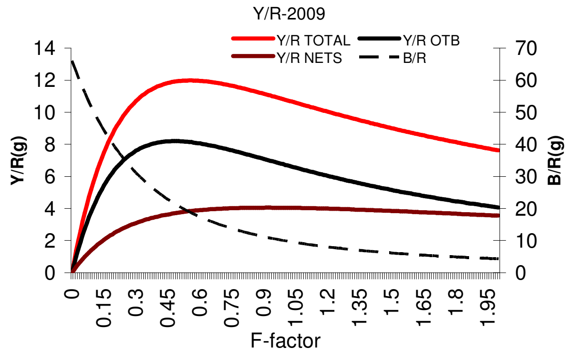




2008	Factor	F	Y/R	B/R	SSB	Y/R OTB	Y/R NETS
F(0)	0	0	0	66.012	60.724	0	0
F(0.1)	0.32	0.44064	13.62	28.19	23.455	5.987	7.633
Fmax	0.49	0.67473	14.225	21.153	16.651	6.733	7.492
Fcurr	1.01	1.377	12.7	11.617	7.73	7.366	5.334
Fdouble	2	2.754	9.808	6.27	3.196	6.691	3.117

2009	Factor	F	Y/R	B/R	SSB	Y/R OTB	Y/R NETS
F(0)	0	0	0	66.012	60.724	0	0
F(0.1)	0.4	0.3916	11.594	25.204	20.885	8.099	3.495
Fmax	0.56	0.54824	11.981	18.981	14.951	8.147	3.833
Fcurr	0.93	0.979	11.072	10.957	7.518	7.015	4.058
Fdouble	2	1.958	7.626	4.354	2.044	4.07	3.556





2010	Factor	F	Y/R	B/R	SSB	Y/R OTB	Y/R NETS
F(0)	0	0	0	73.525	68.237	0	0
F(0.1)	0.37	0.37666	12.48	25.772	21.25	8.32	4.159
Fmax	0.54	0.54972	12.911	18.499	14.232	9.11	3.801
Fcurr	1.01	1.018	11.673	9.635	5.953	8.953	2.72
Fdouble	2	2.036	8.959	5.015	2.148	7.009	1.95

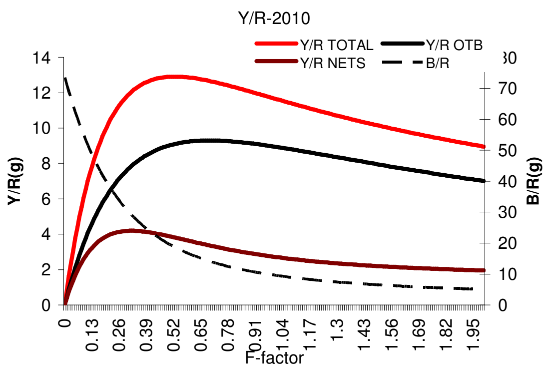


Fig. 6.2.5.3.1. Y/R curves by gear and year from VIT analysis. For each year the overall estimates regarding F-factor, F (F_0, $F_{0.1}$, F_{max}, F_{curr}, F_{double}), overall and by gear Y/R, B/R and SSB are reported.

6.2.6 *Data quality and availability*

Data from DCF 2011 were used. Assessments were performed for the new submitted time series. Comparisons with past assessments (SGMED 03-2010 report) evidence some variations, but estimates were consistent. A consistent sum of products was observed (less than 10%).

6.2.7 *Scientific advice*

6.2.7.1 Short term considerations

6.2.7.1.1 State of the spawning stock size

EWG 11-20 is unable to fully evaluate the state of the spawning stock due to the absence of proposed or agreed management reference points. However, survey indices indicate a variable pattern of abundance indices with the recent values amongst the lowest observed and a decrease pattern of biomass indices.

6.2.7.1.2 State of recruitment

In 2007 and 2009 the MEDITS surveys indicated high indices of recruit abundance, while in 2010 the index was among the lower observed in the time series.

6.2.7.1.3 State of exploitation

EWG 11-20 proposes $F_{0.1} \leq 0.4$ (geometric mean of the last 3 years) as limit management reference point consistent with high long term yields. Thus, given the results of the present analysis (F 2006=1.3, F 2007=0.76, F 2008=1.38; F 2009=0.98, F 2010=1.01), the stock appeared to have been subject to overfishing during 2006-2010. A reduction of F of about 62% would be thus necessary in order to avoid future loss in stock productivity and landings.

6.3 Stock assessment of pink shrimp in GSA 10

6.3.1 Stock identification and biological features

6.3.1.1 Stock Identification

The stock of pink shrimp was assumed in the boundaries of the whole GSA10, lacking specific information on the stock identification. The pink shrimp is an epibenthic species and inhabits the muddy or sandy-muddy bottoms of the continental shelf. A gradient of size increasing with depth has been observed in GSA 10 as in other areas, being the smallest specimens fished more frequently in the upper part of the continental shelf (100-200 m), while the largest ones are mainly distributed along the slope at depths greater than 200 m (Spedicato *et al*., 1996). Aggregations with higher abundance were localised between 100 and 200 m depth, with some intrusions in the deeper waters in three sub-areas. Two most important patches were located in the Gulf of Naples and along the Calabrian coasts in correspondence with Cape Bonifati, while a third one in the Gulf of Salerno (Lembo *et al*., 1999). These are the areas where also the main nurseries are localised (Lembo *et al*., 2000a). In the Central-Southern Tyrrhenian Sea the occurrence of mature females was observed in spring (May), summer (July-August) and autumn (October), with a higher relative frequency in spring-summer seasons (Spedicato et al., 1996). Thus, a continuous recruitment pattern is shown which, however, exhibits a main pulse in the autumn season. At 16 mm carapace length the pink shrimp is considered recruited to the grounds (SAMED, 2002). The overall sex ratio is about 0.5. The structure of the sizes of *P. longirostris* is characterised by differences in growth between the sexes, the larger individuals being females. The pink shrimp is a short-living crustaceans with a life span of about 4 years (Carbonara *et al*., 1998).

The deep-water rose shrimp with hake and red mullet is a key species of fishing assemblages in the central-southern Tyrrhenian Sea. In the last decade it is generally also ranked among the species with higher abundance indices (number of individuals) in the trawl surveys (e.g. Spedicato *et al*. 2003) as observed for different Mediterranean areas (Abella *et al*., 2002). The pink shrimp is caught on the same fishing grounds as European hake and the production of this shrimp is steadily growing in the last decade in the southern basin and it reached in 2006 about 10% of the demersal landings.

6.3.1.2 Growth

Past estimates of the growth pattern of the pink shrimp females were obtained using different methods based on the LFD analysis (modal progression analysis-MPA, Elefan, Multifan) applied to GRUND data from 1990 to 1995. Parameters of VBGF were as follows: L_∞=45.9; K=0.673 t_0= -0.251 (Carbonara *et al.*, 1998). VBGF parameters were also re-estimated during the Samed project (SAMED, 2002) using the MEDITS time series from 1994 to 1999, that gave the following values: females: CL_∞=45.0 mm, K=0.7, t_0= -0.15; males: CL_∞=40.0 mm; K=0.78; t_0= -0.2. Maximum carapace lengths (CL) observed for females and males were respectively 42.3 mm and 39 mm. The growth parameters from DCF (2006-2008) are as follows: females CL_∞=46 mm, K=0.575, t_0= -0.2; males CL_∞=40 mm, K=0.68, t_0= -0.25. They also describe a fast growing pattern albeit slightly lower than that previously observed. The length weight relationships by sex and for sex combined are as follows: females: a=0.935, b=2.452; males a=0.974; b=2.335 sex combined a=0.920; b= 2.445.

6.3.1.3 Maturity

The maturity ogive Fig. 6.3.1.3.1 was obtained from a maximum likelihood procedure applied grouping as mature individuals belonging to the maturity stage 2b-2e (according to the Medits maturity scale). The fitting of the curve was fairly good, however the estimates of the size at first maturity $L_{m50\%}$ (18.7 cm ±0.06 cm) and of the maturity range (0.31 cm ±0.009 cm), reported in the figure below, seem underestimated if compared with literature values (average of the smallest females 24 mm CL; in Relini et al., 1999).

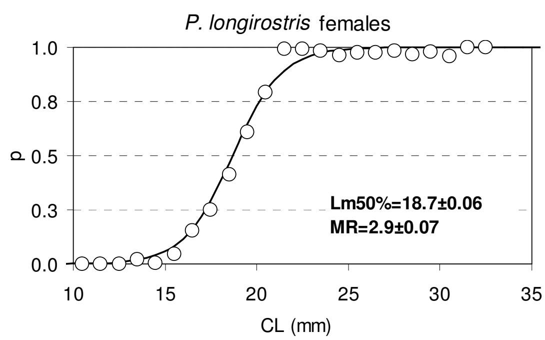


Fig. 6.3.1.3.1 Maturity ogive of pink shrimp in the GSA10 (MR indicates the difference $Lm_{75\%}$-$Lm_{25\%}$).

The sex ratio from DCF (2006-2008 data) evidenced the prevalence of males between 1.4 and 2.0 cm, while from 2.4 cm onwards the proportion of females was dominant (Fig. 6.3.1.3.2).

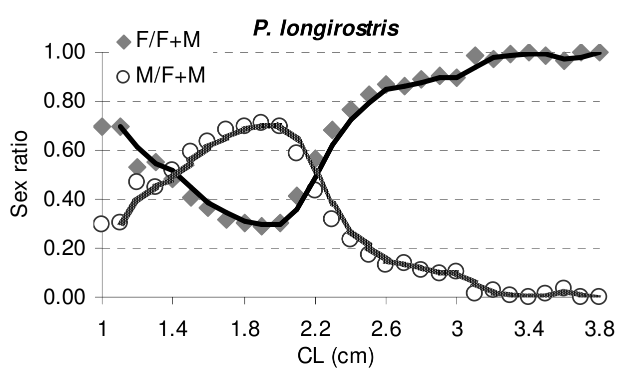


Fig. 6.3.1.3.2 Sex ratio over length of pink shrimp in the GSA10.

6.3.2 Fisheries

6.3.2.1 General description of fisheries

The pink shrimp is only targeted by trawlers and fishing grounds are located on the soft bottoms of continental shelves and the continental slope along the coasts of the whole GSA. The pink shrimp occurs mainly with *M. merluccius*, *M. barbatus*, *Eledone cirrhosa*, *Illex coindetii* and *Todaropsis eblanae, N. norvegicus*, *P. blennoides*, depending on depth and area.

6.3.2.2 Management regulations applicable in 2009 and 2010

Management regulations are based on technical measures, closed number of fishing licenses for the fleet and area limitation (distance from the coast and depth). In order to limit the over-capacity of fishing fleet, the Italian fishing licenses have been fixed since the late eighties. Other measures on which the management regulations are based regard technical measures (mesh size) and minimum landing sizes (EC 1967/06).

After 2000, in agreement with the European Common Policy of Fisheries, a gradual decreasing of the fleet capacity is implemented. Along northern Sicily coasts two main Gulfs (Patti and Castellammare) have been closed to the trawl fishery up 200 m depth, since 1990.

In the GSA 10 the fishing ban has not been mandatory along the time, and from one year to the other it was adopted on a voluntary basis by fishers, whilst in the last years it was mandatory. Regarding long-lines the management regulations are based on technical measures related to the number of hooks and the minimum landing sizes (EC 1967/06), besides the regulated number of fishing licences.

In 2008 a management plan was adopted, that foresaw the reduction of fleet capacity associated with a reduction of the time at sea. Two biological conservation zone (ZTB) were permanently established in 2009 (Decree of Ministry of Agriculture, Food and Forestry Policy of 22.01.2009; GU n. 37 of 14.02.2009). One is located along the mainland, in front of Sorrento peninsula in the vicinity of the MPA of Punta Campanella (Napoli Gulf, 60 km^2, within 200 m depth) and a second one is along the coasts of Amantea (Calabrian coasts, 75 km^2 up to 250 m depth). In these areas trawling is forbidden and other fishing activities are allowed under permission. Since June 2010 the rules implemented in the EU regulation (EC 1967/06) regarding the cod-end mesh size and the operative distance of fishing from the coasts are enforced.

6.3.2.3 Catches

6.3.2.3.1 Landings

Available landing data are from DCF regulations. EWG 11-20 received Italian landings data for GSA 10 by fishing gears which are listed in Table 6.3.2.3.1.1. Almost all landings are from trawlers. Nevertheless, a gradual slight decrease in the production in the last 4 years was noticed, from 534 tons in 2007 to 370 tons in 2010.

Table 6.3.2.3.1.1. Annual landings (in tons) by gear type, 2004-2010.

Species	Area	Country	Gear	Fishery	2004	2005	2006	2007	2008	2009	2010
DPS	10	ITA			2	1					
			GNS	DEMF	3	6					
			GTR	DEMSP	3						
			LLS	DEMF		26					
			OTB	DEMSP			17	2	5	14	242
			OTB	DWSP	151		391	180	226	197	3
			OTB	MDDWSP	393	743	679	353	169	168	125
			Total		552	776	1088	534	400	379	370

The catches of the species raised from 2004 to 2006 when 1089 tons were recorded and then declined to 370 tons in 2010.

6.3.2.3.2 Discards

9 t of discards in 2006, 5t in 2009 and 2 t in 2010 was reported to EWG 11-20 through the DCR data call.

6.3.2.4 Fishing effort

Trend in fishing effort (kW*days) for GSA 10 by gear type, for 2004 to 2010 as reported through the DCF official data call is in the Tab. 6.3.2.4.1.

Table 6.3.2.4.1. Trend in nominal effort (kW*days) for GSA10 by major gear types, 2004-2010. Data submitted through the DCF data call in 2011.

Area	Gear	Fishery	2004	2005	2006	2007	2008	2009	2010	Total
	-1	-1	5212242	3873979	3255356	2531896	1924958	2018775	1426305	20243511
		CEP	599410	425518	412143	342733	788684	1114012	613164	4295664
		DEMSP	704007	202984	114568	33279	123312	23990	171509	1373649
		FINF	1696	3455	1767	18469			1928	27315
	DRB	MOL	86117	294424	312180	144186	241664	188909	206550	1474030
	FPO	DEMSP	0	312076	148868					460944
	GND	SPF	281464	128070	622561	442465	470435	440882	103959	2489836
	GNS	DEMSP	4047979	5028180	2953928	2052278	2467212	2544508	2520971	21615056
		SLPF	1556			94137	1910	30214	12173	139990
SA 10	GTR	DEMSP	3374829	1739878	4295352	3854825	3105046	2480175	2522528	21372633
	LLD	LPF	1044137	1135956	791936	404235	353211	1287002	1660409	6676886
	LLS	DEMF	4563483	1810269	1434965	1194701	1316931	885225	973619	12179193
	LTL	LPF	0							0
	OTB	DEMSP	3648016	72338	1491604	1528297	3743680	3482911	3576824	17543670
		DWSP			246152	82495	116434	239720	289440	974241
		MDDWSP	4422360	7956395	5762828	5676419	2382266	2563895	1809087	30573250
	PS	LPF	1254287	807500	96501	186494	243450	1076308	475177	4139717
		SPF	3330804	2173517	1844148	1807146	973629	1623539	1075689	12828472
	PTB	SPF	6173							6173

6.3.3 Scientific surveys

6.3.3.1 MEDITS

6.3.3.1.1 Methods

According to the MEDITS protocol (Bertrand et al., 2002), trawl surveys were yearly (May-July) carried out, applying a random stratified sampling by depth (5 strata with depth limits at: 50, 100, 200, 500 and 800 m; each haul position randomly selected in small sub-areas and maintained fixed throughout the time). Haul allocation was proportional to the stratum area. The same gear (GOC 73, by P.Y. Dremière, IFREMER-Sète), with a 20 mm stretched mesh size in the cod-end, was employed throughout the years. Detailed data on the gear characteristics, operational parameters and performance are reported in Dremière and Fiorentini (1996). Considering the small mesh size a complete retention was assumed. All the abundance data (number of fish and weight per surface unit) were standardised to square kilometre, using the swept area method.

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 10 the following number of hauls was reported per depth stratum (Tab. 6.3.3.1.1.1).

Table 6.3.3.1.1.1. Number of hauls per year and depth stratum in GSA 10, 1994-2010.

GSA 10	Year																
Stratum	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
10-50 m	7	8	8	8	8	8	8	8	6	7	7	7	7	7	7	7	7
50-100 m	10	10	10	10	10	10	10	10	9	8	8	8	8	8	8	8	8
100-200 m	17	17	17	17	17	17	17	17	14	14	14	14	14	14	14	14	14
200-500 m	22	22	22	22	22	22	22	24	18	18	18	18	18	18	19	18	18
500-800 m	28	28	28	28	28	27	28	26	23	23	23	23	23	23	22	23	23
Total	84	85	85	85	85	84	85	85	70	70	70	70	70	70	70	70	70

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$Yst = \Sigma (Yi*Ai) / A$

$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$

Where:

A=total survey area

Ai=area of the i-th stratum

si=standard deviation of the i-th stratum

ni=number of valid hauls of the i-th stratum

n=number of hauls in the GSA

Yi=mean of the i-th stratum

Yst=stratified mean abundance

V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

6.3.3.1.2 Geographical distribution patterns

Data on the the geographical distribution pattern of pink shrimp come from studies conducted in the area using trawl-survey data, length frequency distribution analyses and geostatistical methods (Lembo *et al*., 2000a). The indicator kriging approach combined with a persistence analysis showed that the nurseries of the pink shrimp were localised with higher level of probability offshore Cape Bonifati (Calabria coasts) Napoli and Salerno Gulfs between 100 and 200 m depth (Figure 6.3.3.1.2.1).

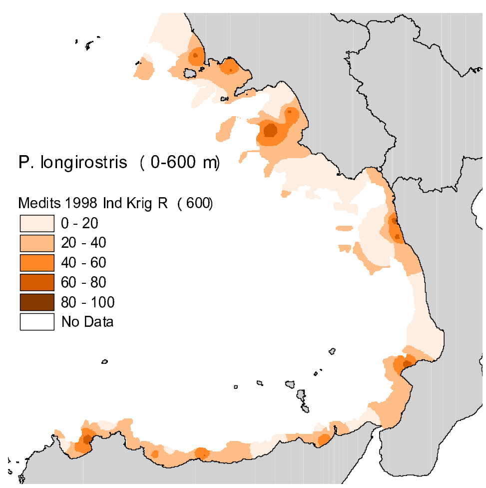


Fig. 6.3.3.1.2.1. Map of pink shrimp nursery area.

6.3.3.1.3 Trends in abundance and biomass

Fishery independent information regarding the state of pink shrimp in GSA 10 was derived from the international survey MEDITS. Figure 6.3.3.1.3.1 displays the estimated trend of *P. longirostris* abundance and biomass standardized to the surface unit in GSA 10. Indices from MEDITS trawl-surveys show two peaks in 1999 and 2005, but without any trend. From 2005 onwards the indices are decreasing and commercial catches follow a similar pattern.

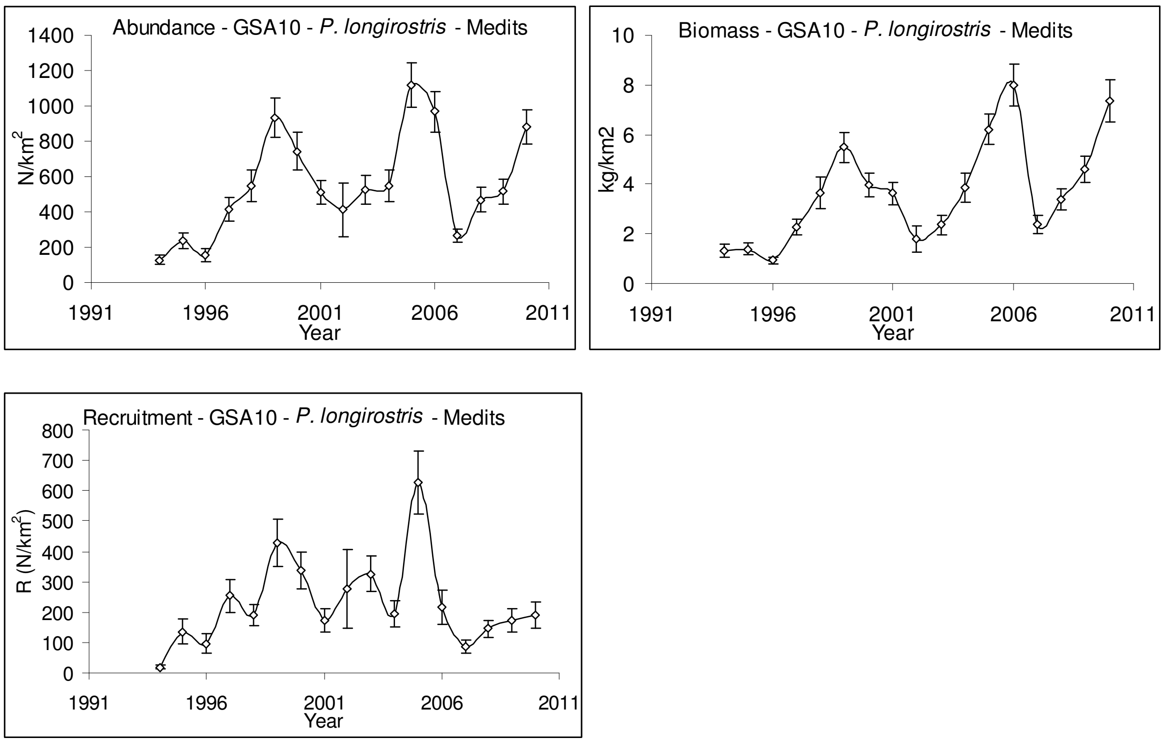


Fig. 6.3.3.1.3.1. Trends in survey abundance and biomass indices standardized to the surface unit and derived from MEDITS (bars indicate standard deviations). Abundance of recruits is also reported.

The re-estimated abundance indices (Figure 6.3.3.1.3.2) show the same temporal pattern.

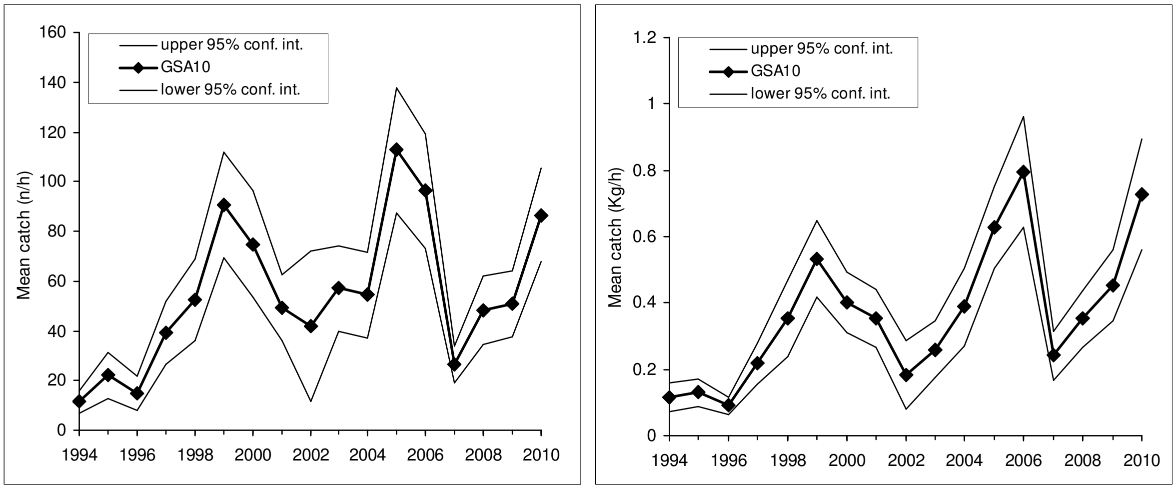


Fig. 6.3.3.1.3.2. Trends in survey abundance and biomass indices (MEDITS) of pink shrimp in GSA 10.

6.3.3.1.4 Trends in abundance by length or age

The following Fig. 6.3.3.1.4.1, 6.3.3.1.4.2, 6.3.3.1.4.3 display the stratified abundance indices of GSA 10 in 1994-2001, 2002-2009 and 2010.

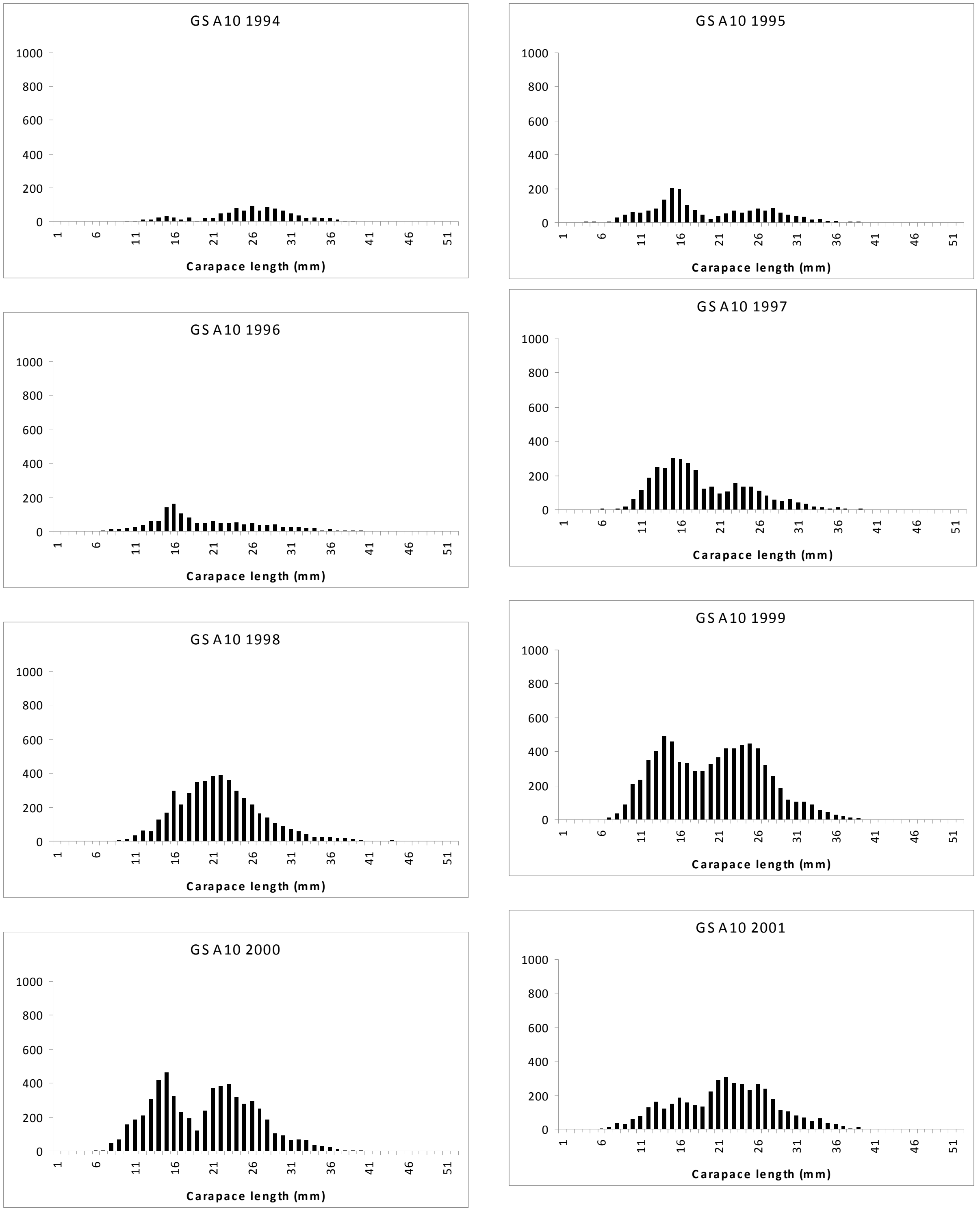
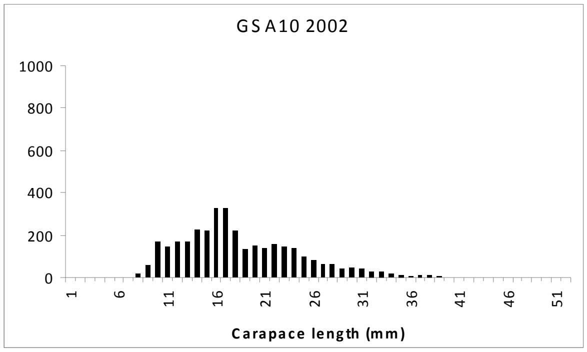
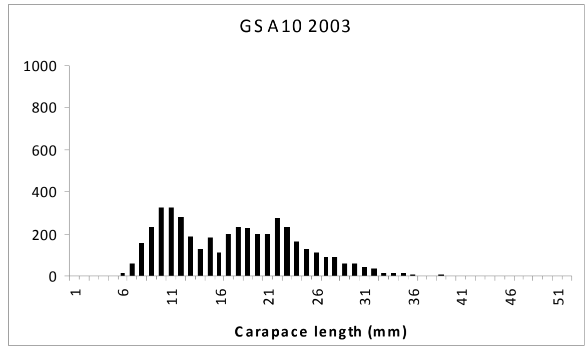
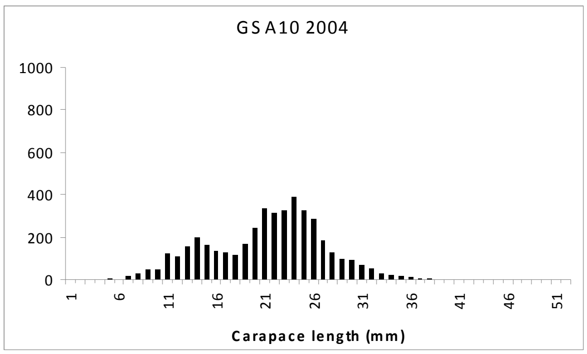
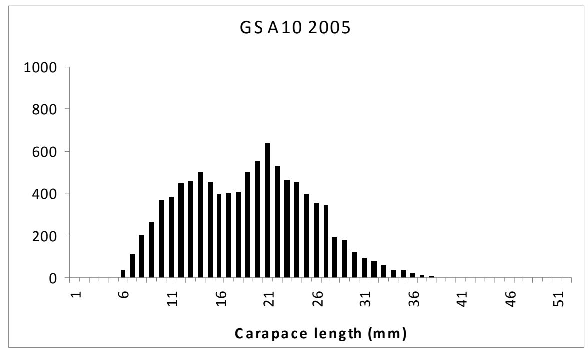


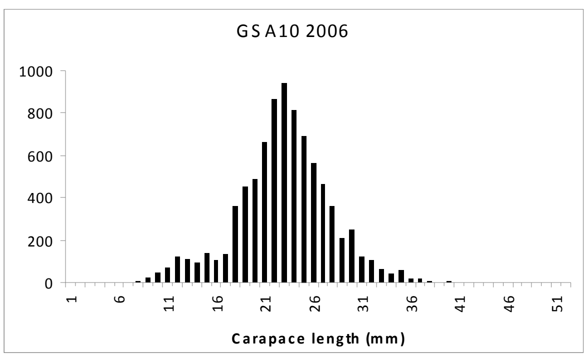
Fig. 6.3.3.1.4.1. Stratified abundance indices by size, 1994-2001.

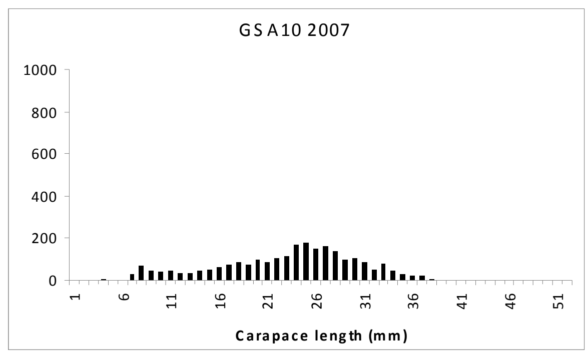

GSA10 2002
1000
800
600
400
200
0
1 6 11 16 21 26 31 36 41 46 51
Carapace length (mm)

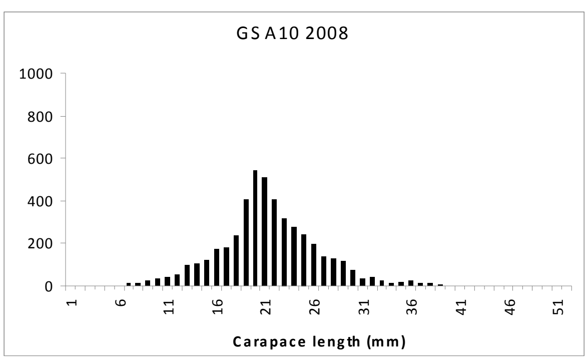

GSA10 2003
1000
800
600
400
200
0
1 6 11 16 21 26 31 36 41 46 51
Carapace length (mm)


GSA10 2004
1000
800
600
400
200
0
1 6 11 16 21 26 31 36 41 46 51
Carapace length (mm)


GSA10 2005
1000
800
600
400
200
0
1 6 11 16 21 26 31 36 41 46 51
Carapace length (mm)


GSA10 2006
1000
800
600
400
200
0
1 6 11 16 21 26 31 36 41 46 51
Carapace length (mm)


GSA10 2007
1000
800
600
400
200
0
1 6 11 16 21 26 31 36 41 46 51
Carapace length (mm)


GSA10 2008
1000
800
600
400
200
0
1 6 11 16 21 26 31 36 41 46 51
Carapace length (mm)

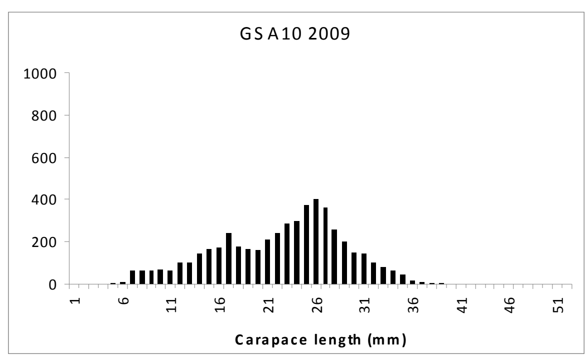

GSA10 2009
1000
800
600
400
200
0
1 6 11 16 21 26 31 36 41 46 51
Carapace length (mm)

Fig. 6.3.3.1.4.2. Stratified abundance indices by size, 2002-2009.

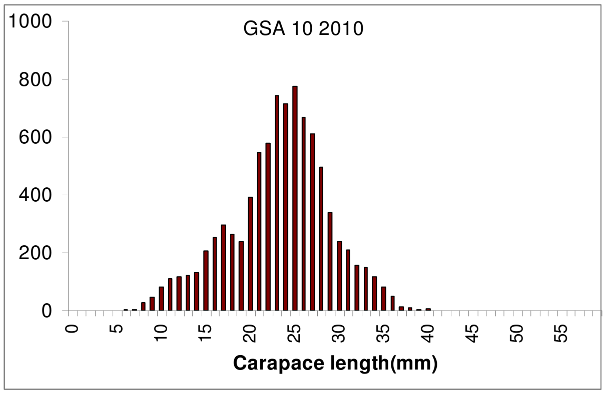


Fig. 6.3.3.1.4.3. Stratified abundance indices by size in 2010.

No trend in the length indicators was observed in MEDITS survey (Figure 6.3.3.1.4.4) except for the quantiles that show a slightly rising trend.

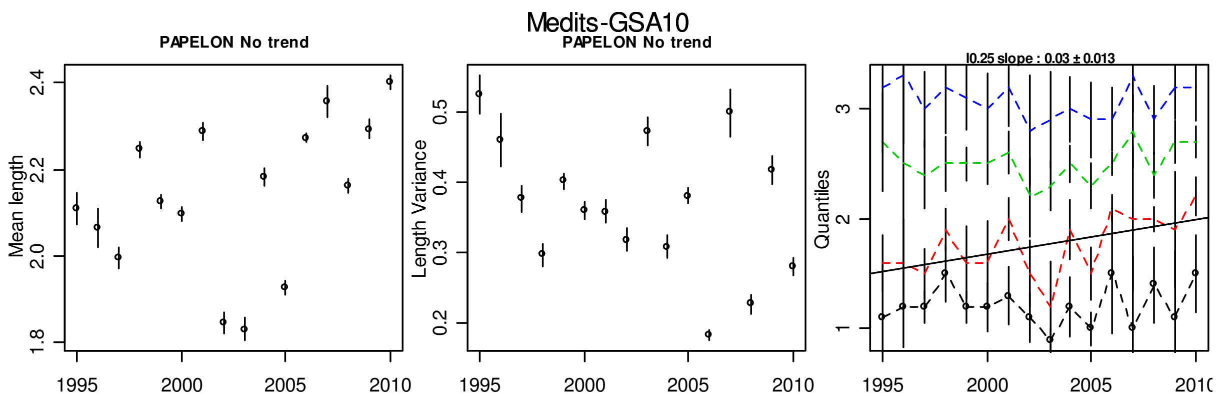


Fig. 6.3.3.1.4.4. Mean length, variance and quantiles derived from the MEDITS length compositions.

6.3.3.2 GRUND

6.3.3.2.1 Methods

GRUND survey trends were estimated and are shown in the following sections.

6.3.3.2.2 Geographical distribution patterns

No analyses were conducted during EWG 11-20.

6.3.3.2.3 Trends in abundance by length or age

Trends derived from the GRUND surveys are shown in figure 6.3.3.2.3.1. Abundance and biomass indices as well as recruitment indices, show an increasing trend up to 2005 and a decreasing since 2006 (Figure 6.3.3.2.3.1). In 1999 the survey was not performed.

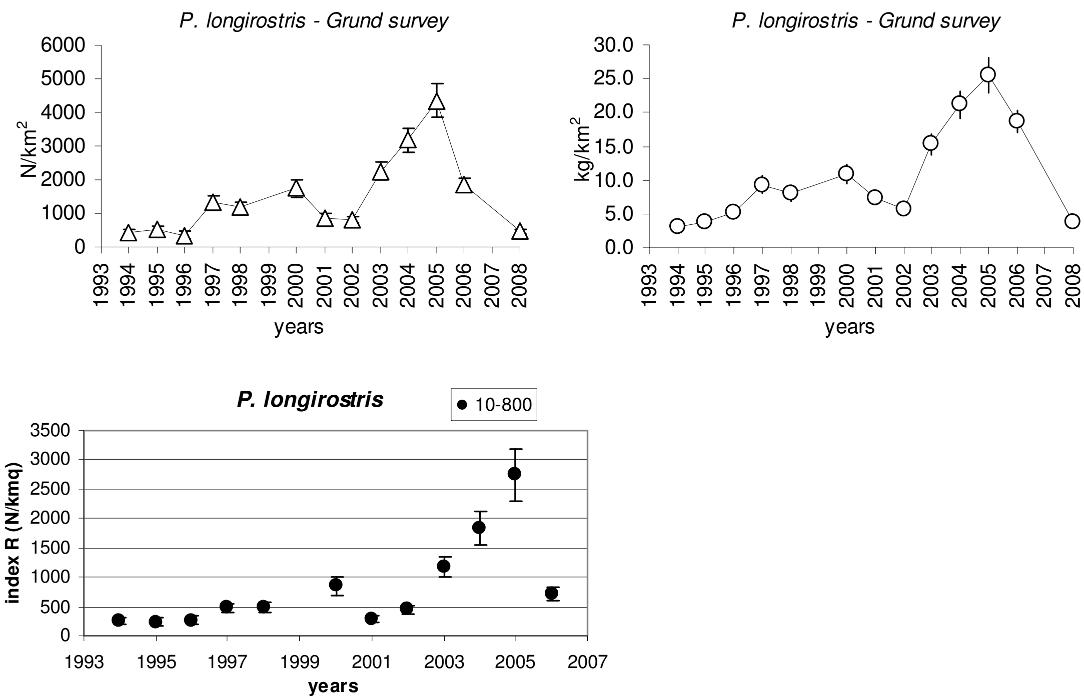


Fig. 6.3.3.2.3.1. Abundance and biomass indices of the pink shrimp in GSA 10 (bars indicate standard deviations) derived from GRUND surveys. Recruitment indices (N/km^2) computed in the total depth range with standard deviation is also reported.

6.3.3.2.4 Trends in abundance by length or age

Also time series of length structures of GRUND from 1994 to 2006 (Figure 6.3.3.2.4.1) did not show any trend.

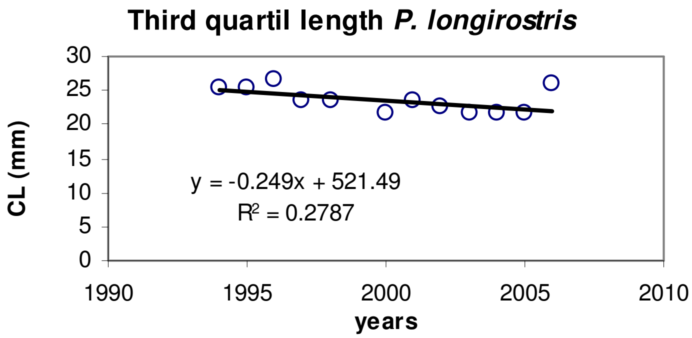


Fig. 6.3.3.2.4.1. III Quantile derived from the GRUND length structures in 1994-2006.

6.3.3.2.5 Trends in growth

No analyses were conducted during EWG 11-20.

6.3.3.2.6 Trends in maturity

No analyses were conducted during EWG 11-20.

6.3.4 Assessment of historic stock parameters

EWG 11-20 applied the VIT model to commercial landings.

6.3.4.1 Method 1: VIT

6.3.4.1.1 Justification

VIT software was applied using the landing structures at age of 2006, 2007, 2008, 2009 and 2010 from DCF. Five analyses were performed (one for each year).

6.3.4.1.2 Input parameters

A sex combined analysis was carried out using the following growth parameters:

CL_∞ = 4.6 cm, K= 0.575, t_0= -0.2; length-weight relationship: a = 0.935, b = 2.4523.

The vector of natural mortality M was estimated using Prodbiom (Abella *et al.*, 1998) and terminal fishing mortality F_{term}= 1 was assumed. The number of individuals in landing, natural mortality and maturity used as input in VIT are showed below.

Table 6.3.4.1.2.1 Natural mortality and maturity vectors used in 2006-2010.

Age	Natural mortality	Maturity
0	0.47	1.41
1	0.98	0.81
2	1.00	0.70

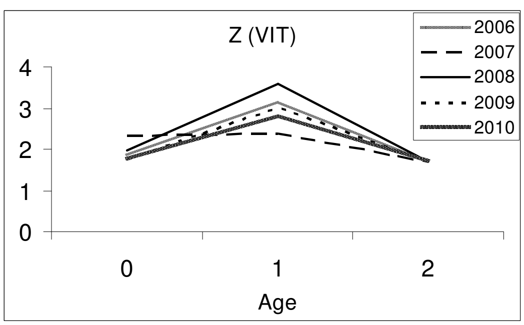
Table 6.3.4.1.2.2. Landings in numbers at age in 2006, 2007, 2008, 2009 and 2010.

	Year				
Age	**2006**	**2007**	**2008**	**2009**	**2010**
0	101,115,238	92,896,295	43,581,327	29,458,044	28,026,938
1	54,976,141	15,155,212	18,778,285	22,328,805	20,206,463
2	1,571,296	1,121,270	329,599	750,209	1,089,813

6.3.4.1.3 Results

Estimates of total and fishing mortality at age for sex combined by VIT are plotted in the figure 6.3.4.1.3.1.

The mortality acting on the age groups shows values changing from 1.17 in 2007 to 1.45 in 2008, with an average over the last three years of 1.25 and a value of 1.1 in 2010.



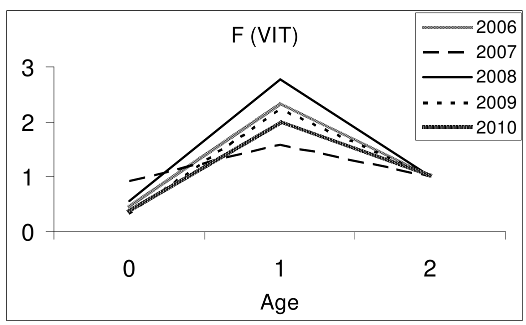


Fig. 6.3.4.1.3.1. Total and fishing mortality by age as estimated by the cohort analysis using VIT, by year (2006-2010).

6.3.5 Long term prediction

Two assessment approaches were applied for long term predictions, the VIT and secondly the YIELD software.

6.3.5.1 Method 1: VIT

6.3.5.1.1 Justification

The cohort analysis and the Y/R approach as implemented in the VIT software under equilibrium conditions were used, then VIT and YIELD results were compared.

6.3.5.1.2 Input parameters

Input parameters are given in section 6.3.4.1.2 on the VIT assessment above.

6.3.5.1.3 Results

Results of the YPR analysis from the VIT are shown in the table 6.3.5.1.3.1 and in the figure 6.3.5.1.3.1. The Yield per Recruit analyses indicate that the reference point $F_{0.1}$ is on average 0.71(last three years) . The YPR curve of 2010 is slightly dome-shaped.

Table 6.3.5.1.3.1. Overall results of Y/R analysis for 2006-2010.

2006	Factor	F	Y/R	B/R	SSB
F(0)	0	0.00	0.00	4.79	4.12
F(0.1)	0.61	0.77	1.53	2.00	1.45
Fmax	0.88	1.11	1.58	1.58	1.07
Fcurr	1.01	1.27	1.57	1.43	0.94
Fdouble	2	2.53	1.38	0.85	0.48
2007	Factor	F	Y/R	B/R	SSB
F(0)	0	0.00	0.00	4.79	4.12
F(0.1)	0.59	0.69	1.31	1.87	1.40
Fmax	0.8	0.93	1.35	1.46	1.04
Fcurr	1.01	1.17	1.32	1.15	0.78
Fdouble	2	2.33	1.07	0.51	0.29
2008	Factor	F	Y/R	B/R	SSB
F(0)	0	0.00	0.00	4.79	4.12
F(0.1)	0.52	0.75	1.51	1.98	1.44
Fmax	0.76	1.10	1.56	1.54	1.04
Fcurr	1.01	1.45	1.53	1.24	0.79
Fdouble	2	2.90	1.29	0.72	0.39
2009	Factor	F	Y/R	B/R	SSB
F(0)	0	0.00	0.00	4.79	4.12
F(0.1)	0.67	0.79	1.57	2.05	1.48
Fmax	0.99	1.17	1.63	1.61	1.09
Fcurr	1.01	1.18	1.63	1.59	1.07
Fdouble	2	2.37	1.49	1.00	0.58
2010	Factor	F	Y/R	B/R	SSB
F(0)	0	0.00	0.00	7.24	6.56
F(0.1)	0.53	0.59	1.57	2.66	2.08
Fmax	0.9	1.00	1.65	1.84	1.30
Fcurr	1.01	1.11	1.65	1.68	1.17
Fdouble	2	2.22	1.49	1.02	0.60

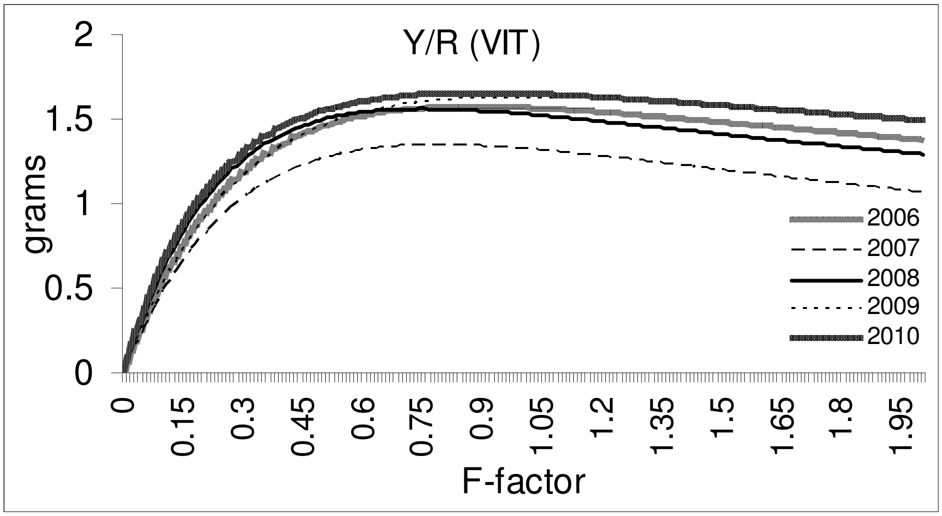


Fig. 6.3.5.1.3.1. Y/R curves for 2006-2010.

6.3.5.2 Method 2: YIELD

6.3.5.2.1 Justification

A yield per recruit analyses was conducted also using the Yield software, in order to obtain a point estimate with the associated variability for the reference point to be used in the advice and for comparison with the VIT analysis.

6.3.5.2.2 Input parameters

The same growth and natural mortality parameters used in VIT were also the input to Yield. The parameters were however converted in TL (growth parameters and length-weight relationship coefficients) in order to parameterize the YIELD software: TL_{∞} = 20.77 cm, K= 0.575, t_0= -0.23, a= 0.0178, b= 2.5423. The conversion from CL to TL was obtained by the following relationship: TL=2.98+4.47*CL, from Crosnier *et al.*, 1970.

Both total length at first maturity of 8.13 cm (normally distributed, coefficient of variation (CV)= 0.01), according to the maturity ogive derived in the area and a total length at first capture of 6.57 cm (normally distributed, CV=0.01) were the inputs in the YIELD software. Finally, it was fixed a constant recruitment of 360 million individuals (CV=0.2) that was derived averaging the 2006-2010 age 0 classes computed by VIT.

6.3.5.2.3 Results

The results from Yield analysis are reported in Table 6.3.5.2.3.1.

Table 6.3.5.2.3.1. Results of Y/R analysis from YIELD.

Fmax	Y/R (g)	F0.1	Y/R (g)
1.30	2.42	0.66	2.23

6.3.6 Data quality and availability

Data from DCF 2011 were used. Assessments were performed for the new submitted time series. Comparisons with past assessments (SGMED 03-2010 report) evidence only little variations and consistent estimates. A consistent sum of products was observed (less than 10%).

6.3.7 Scientific advice

6.3.7.1 Short term considerations

6.3.7.1.1 State of the spawning stock size

In the absence of proposed and agreed precautionary management references, EWG 11-20 is unable to fully evaluate the status of SSB. Survey indices indicate a variable pattern of abundance (n/h) and biomass (kg/h) that was increasing in the last years. MEDITS indices indicate a sharp decrease from 2006 to 2007 and then a slight increase. GRUND data showed a decrease of abundance and biomass from 2005 to 2006 after a rising phase.

6.3.7.1.2 State of recruitment

Recruitment estimates from GRUND surveys showed a decrease in abundance from 2005 to 2006 after a rising phase from 2002 to 2005, whilst recruit indices from MEDITS were among the lower in the time series.

6.3.7.1.3 State of exploitation

EWG 11-20 proposes $F \leq 0.71$ as limit management reference point (basis $F_{0.1}$ as proxy of F_{MSY}) of exploitation consistent with high long term yield. Given the results of the present analysis (F_{curr} (2010) = 1.1), the stock is considered subject to overfishing during the period 2006-2010. EWG 11-20 recommends the relevant fleets' effort to be reduced to reach the proposed level $F_{0.1}$, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan. However the dynamics of this species seems also influenced by environmental changes.

6.4 Stock assessment of European hake in GSA 11

6.4.1 Stock identification and biological features

6.4.1.1 Stock Identification

This stock is assumed to be confined within the GSA 11 boundaries, where it is distributed between 30 and 650 m of depth, with a peak in abundance (due to high number of recruits) over the continental shelf-break (between 150 and 250 m depth). The stock is mainly exploited by the local fishing fleet, although seasonally and occasionally some other Italian fleet use to fish in some areas of the GSA 11. Spawning is taking place almost all year round, with a peak during winter –spring.

Juveniles showed a patchy distribution with some main density hot spots (nurseries) showing a high spatio-temporal persistence (Murenu *et al*., 2007) in western areas.

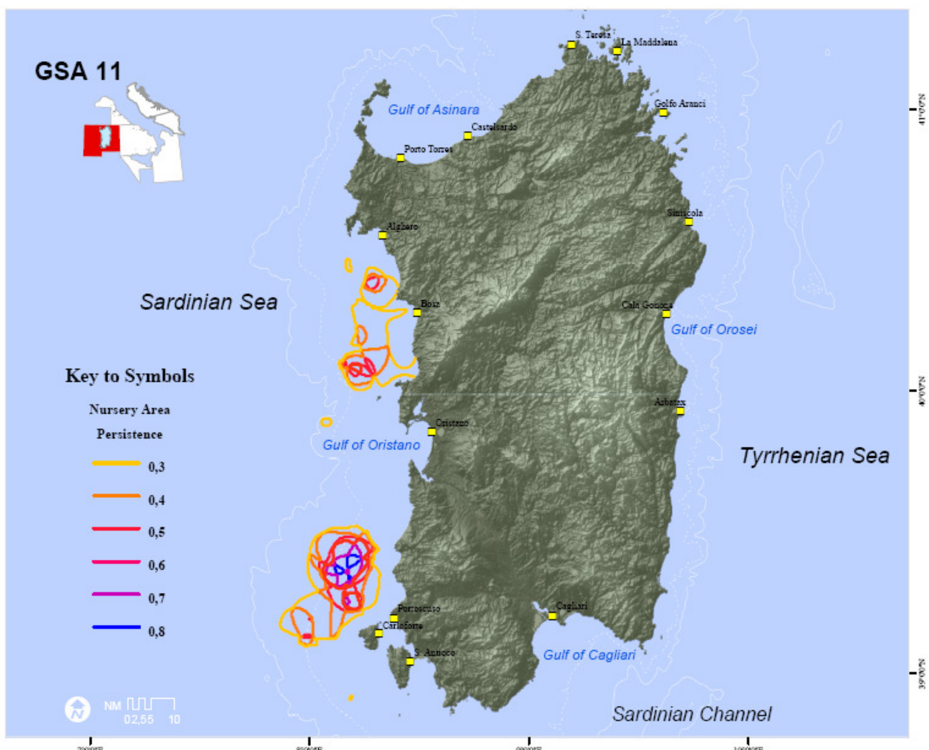


Fig. 6.4.1.1. Temporal persistence of hake nurseries calculated from data survey time-series density maps (1994-2006) of juveniles.

6.4.1.2 Growth

The same fast growth of last EWG 11-12 meeting have been used in this assessment.

6.4.1.3 Maturity

Due to the low catchability of large hake in trawl, the catch rate of mature specimens during the MEDITS trawl survey is usually very low, influencing the identification of gonad development and growth rate for large individuals. Female length at first maturity is estimated at around 36 cm. Although spawning around Sardinian coasts (GSA 11) occurs nearly all over the year (January to September), a maturity peak is usually observed in winter and spring (February-May).

6.4.2 Fisheries

6.4.2.1 General description of fisheries

Hake is one of the most important commercial species in the Sardinian seas. In this area, the biology and population dynamics have been studied intensively in the past fifteen years. Although hake is not a target of a specific fishery, such as for example red shrimp, it is the third species in terms of biomass landed in GSA 11 (Murenu M., pers. com.). In the GSA 11 hake is caught exclusively by a mixed bottom trawl fishery at depth between 50 and 600 m. No gillnet or longline fleets target this species. Although different nets are used in shallow, mid and deep water (“terra” mainly targeting *Mullus* spp., “mezzo fondo” targeting fish and “fondale” net targeting deep shrimp) the main trawl used is an “Italian trawl net” type with a low vertical opening (max up to 1.5 m). The dimensions of the trawl change in relation to the trawlers engine power. Important by catch species are horned octopus, squids, poor cod, shortnose greeneye, greater forkbeard and pink shrimp.

Detailed maps of the fishing-grounds are reported in Murenu *et al*. (2006). Most of the effort is concentrated within a relative short distance around the major fishing ports (Cagliari, Alghero, Porto Torres, La Caletta, Sant’antioco, Oristano, Alghero). Moreover, some large trawlers move seasonally in different fishing grounds far from the usual ports.

From 1994 to 2004, the trawl fleet showed remarkable changes in GSA 11. Those mostly consisted of a general increase in the number of vessels and by the replacement of the old, low tonnage wooden boats by larger steel boats. For the entire GSA an increase of 85% for boats >70 tons class occurred. A decrease of 20% for the smaller boats (<30 GRT) was also observed.

6.4.2.2 Management regulations applicable in 2010 and 2011

As in other areas of the Mediterranean, the management of this stock is based on the control of fishing capacity (licenses), fishing effort (fishing activity), technical measures (mesh size and area closures), and minimum landing sizes (EC 1967/06). Two small closed areas were also established along the mainland (west and east coast respectively) although these are defined to mainly protect Norway lobster. Since 1991, a fishing closure for 45 trawling days has been enforced almost every year (Figure 6.4.2.2.1).

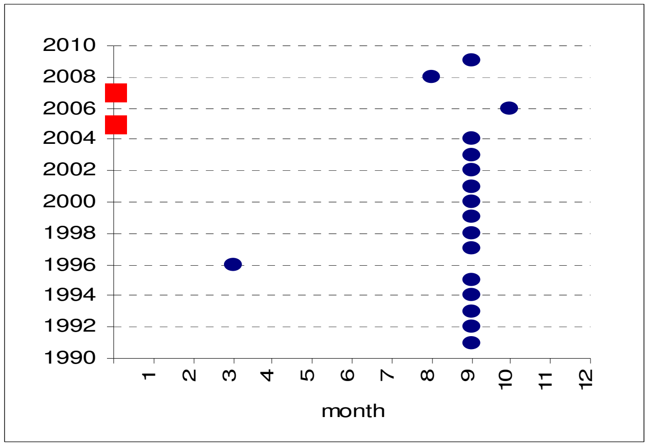


Fig. 6.4.2.2.1. Month and year of the fishing closure. Red points show the years when no closing measure was adopted.

Towed gears are not allowed within the three nautical miles from the coast or at depths less than 50 m when this depth is reached at a distance less than 3 miles from the coast.

6.4.2.3 Catches

6.4.2.3.1 Landings

Landings available for GSA 11 by major fishing gears are listed in Table 6.4.2.3.1.1.

Landings decreased from 866 t (2005) to 268 t in 2009 (Fig. 6.4.2.3.1.1). Landings of hake are mostly taken by the demersal trawl fisheries (OTB) that in average account for about the 88.8% of the total. From data available landings from other gears are mainly from GTR although seems to be misreported in 2007 and 2009.

Table 6.4.2.3.1.1. Landings (in tons) by year and major gear types, 2005-2010 as reported through DCF in 2010.

GEAR	2005	2006	2007	2008	2009	2010
GTR	101	206		28.6		57.7
LLS					7.02	
OTB	765	594	442	279	261	267
total landings (all gears)	866	800	442	307	268	324

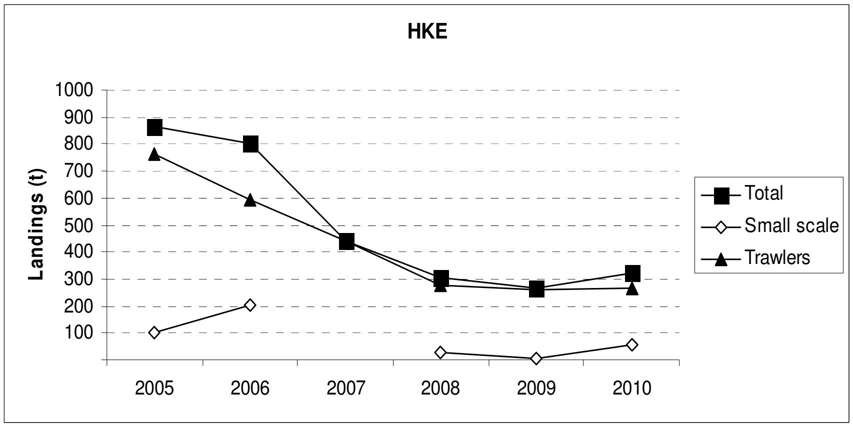


Fig. 6.4.2.3.1.1. Landings (in tons) by year and major gear types, 2005-2010 as reported through DCF.

6.4.2.3.2 Discards

Discards reported to STECF EGW 11-20 were null for 2007 and 2008 as shown in Table 6.4.2.3.2.1. The discard decrease observed in the last two years reflect the drop observed in the same period for total landings.

Table 6.4.2.3.2.1. Discards (in tons) by year, 2005-2010, as reported through DCF in 2010.

	2005	2006	2007	2008	2009	2010
total discards	387	234			169	125

Looking to discard at length data the information seems to be not reliable. Discards data were neither continuous by gear nor by year. Moreover the discard from GTR belongs only to large size specimens, that usually are not discarded by commercial fleets as shown by trawlers' discards data (Figure 6.4.2.3.2.1).

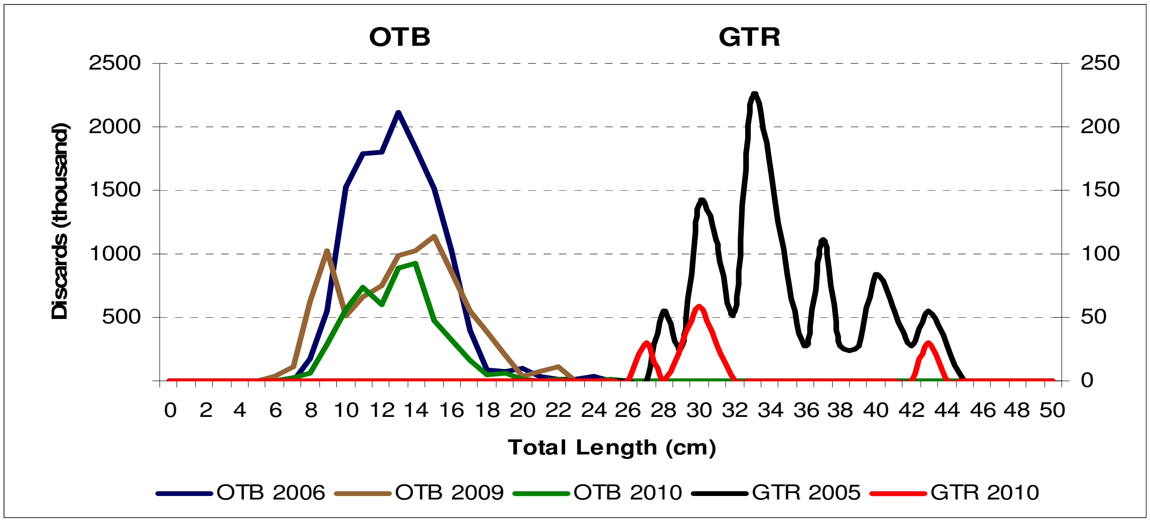


Fig. 6.4.2.3.2.1. Discards (t) by length, year and major gear types, 2005-2010 as reported through DCF.

6.4.2.4 Fishing effort

The reported fishing effort values through the DCF data call was changed and updated for 2010.

Using data available to EWG 11-12, the trends in fishing effort by year and major gear type is listed in Tab. 6.4.2.4.1 and shown in Fig. 6.4.2.4.1 in terms of kW*days. The trend analysis show a major drop of total fishing effort in 2008, when both the trawlers and the small scale fishery effort decrease (of 25 and 31 % respectively). In the last three years the effort was almost stable.

Table 6.4.2.4.1. Trend in fishing effort (kW*days) for Italy in GSA 11 for the major gear types in 2004-2010.

GEAR	2004	2005	2006	2007	2008	2009	2010
FPO	42030	77070	960931	1497019	921315	1039432	999287
FYK				1140			
GNS	1157504	1065868	204874	777750	453491	979982	558828
GTR	6584427	7186648	7227466	4932023	3719222	4103101	4333105
LHP							
LLD	118760	280487	468325	1311593	927405	514982	647982
LLS	1048740	941723	1329827	1135473	649943	672281	530352
LTL			6689	1744	589	566	
none	18500	786	65516	143525	62994	44038	9193
OTB	7706431	7324728	5752588	5865498	4430174	4375729	4041363
PS	27293						
total	16703685	16877310	16016216	15665765	11165133	11730111	11120110

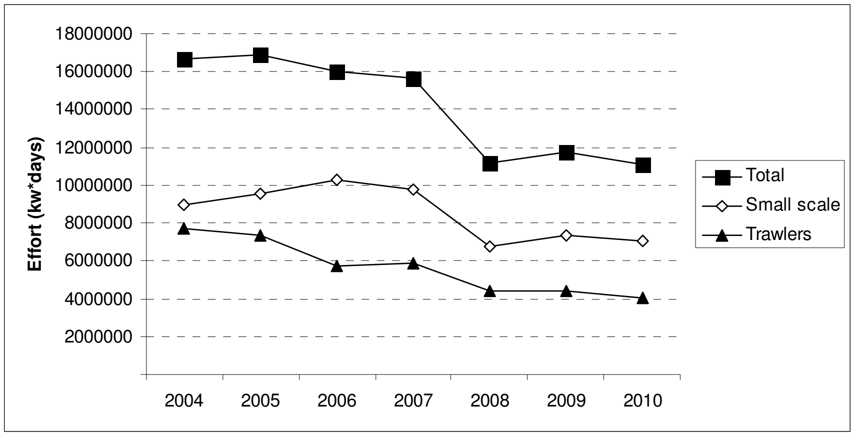


Fig. 6.4.2.4.1. Trend in fishing effort (kW*days) for the Italian fleet in GSA 11 for the major gear types in 2004-2010.

Table 6.4.2.4.2. Trend in fishing effort (kW*days) for Italy in GSA 11 for the major gear types in 2004-2010, as reported through the DCF in 2010.

Gear	Fishery	Vessel_Len	2004	2005	2006	2007	2008	2009	2010
-1	-1	VL1218				18134			
-1	CEP	VL0006				20678	2463		
-1	CEP	VL0612	18500	786	19378	60931	14048	4275	1804
-1	CEP	VL1218			40059	43782	21715	910	
-1	FINF	VL0612			924		24768	38853	7389
-1	FINF	VL1218			5155				
FPO	DEMSP	VL0006				76963	18326	24782	37759
FPO	DEMSP	VL0612	42030	23148	814006	1277817	846628	850868	811483
FPO	DEMSP	VL1218		53922	146925	142239	56361	163782	150045
FYK	DEMSP	VL0006				708	0	0	0
FYK	DEMSP	VL0612				432			
GNS	DEMSP	VL0006			2849	73406	21877	33984	38299
GNS	DEMSP	VL0612	1015513	694933	139688	627676	335747	687764	456896
GNS	DEMSP	VL1218	141991	370935	62337	76668	95867	258234	62966
GNS	SLPF	VL0612							667
GTR	DEMSP	VL0006			177826	113777	82800	75882	75278
GTR	DEMSP	VL0612	5143105	5481274	5787359	3778447	2795301	3228203	3353364
GTR	DEMSP	VL1218	1441322	1705374	1262281	1039799	841121	799016	904463
LLD	LPF	VL0612			114173		6485	6164	16142
LLD	LPF	VL1218	118760	280487	222267	1297228	920920	508818	631840
LLD	LPF	VL2440			131885	14365			
LLS	DEMF	VL0006			11843	17523	2947	3231	0
LLS	DEMF	VL0612	797809	691302	929070	769772	416016	449869	409875
LLS	DEMF	VL1218	250931	250421	297651	324578	230980	219181	120477
LLS	DEMF	VL1824			9933				
LLS	DEMF	VL2440			81330	23600			
LTL	LPF	VL0612			6689	1744	589	566	
OTB	DEMSP	VL0612				1063		152685	193464
OTB	DEMSP	VL1218	1243040	1270821	1475054	134032	1347750	1305105	1176411
OTB	DEMSP	VL1824	55011				829163	700410	571926
OTB	DEMSP	VL2440				19496	259152	218124	138829
OTB	DWSP	VL1218							3769
OTB	DWSP	VL1824							2323
OTB	DWSP	VL2440					139531	199345	270999
OTB	MDDWSP	VL1218				1281844	86074		51154
OTB	MDDWSP	VL1824	2606247	2955031	1870402	1986365	387260	559080	619426
OTB	MDDWSP	VL2440	3802133	3098876	2407132	2442698	1381244	1240980	1013062
PS	SPF	VL1218	27293						
			16703685	16877310	16016216	15665765	11165133	11730111	11120110

6.4.3 Scientific surveys

6.4.3.1 MEDITS

6.4.3.1.1 Methods

Since 1994 the MEDITS trawl surveys have been yearly carried out between May and July (except in 2007).

According to the MEDITS protocol (Relini, 2000; Bertand *et al.*, 2002) a stratified random sampling design with allocation of hauls proportional to depth strata extension (depth strata: 10–50 m, 51–100 m, 101–200 m, 201–500 m, 501–800 m) was adopted. A specific gear (GOC 73, with a 20 mm stretched mesh size in the cod-end) was always used following the instruction stated and reported in Dremière and Fiorentini (1996).

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 11 the following number of hauls was reported per depth stratum (Table 6.4.3.1.1.1).

Table 6.4.3.1.1.1. Number of hauls per year and depth stratum in GSA 11, 1994-2010.

RATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
A11_010-050	16	18	21	21	21	20	19	17	20	18	17	17	19	19	17	18	19
A11_050-100	25	21	22	22	20	22	22	24	19	19	18	21	18	20	19	20	19
A11_100-200	20	23	30	31	31	30	29	30	24	24	24	24	24	24	22	24	24
A11_200-500	33	29	29	26	25	27	24	25	20	24	21	20	20	20	21	19	20
A11_500-800	23	16	21	25	25	24	27	26	16	14	15	14	16	17	16	16	17
al	117	107	123	125	122	123	121	122	99	99	95	96	97	100	95	97	99

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area

Ai=area of the i-th stratum

si=standard deviation of the i-th stratum

ni=number of valid hauls of the i-th stratum

n=number of hauls in the GSA

Yi=mean of the i-th stratum

Yst=stratified mean abundance

V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

6.4.3.1.2 Geographical distribution patterns

The spatial distribution of European hake has been described by modeling the spatial correlation structure of the abundance indices using geostatistical techniques (i.e. kriging). In different studies either total abundance index or abundances of recruits and adults were analysed (Murenu *et al*., 2007).

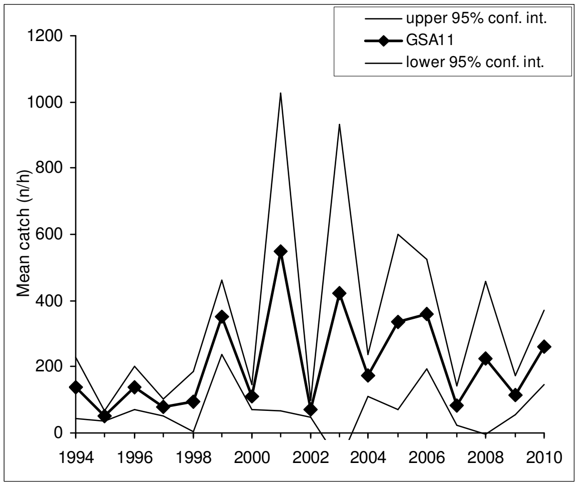
On average, considering the analyzed yearly distributions (1994-2005), the recruits were considered individuals smaller than 12.3 cm (±1.41). These individual are belonging to the age 0 group. Persistence of the nursery areas along the years was studied by applying indicator kriging technique (Journel 1983, Goovaerts, 1997) to abundance estimations of recruits (Murenu *et al*., 2008).

Main results and maps are reported in the "nursery section" of SGMED 09-02 report.

6.4.3.1.3 Trends in abundance and biomass

Fishery independent information regarding the state of the hake in GSA 11 was derived from the international survey MEDITS. Figure 6.4.3.1.3.1 displays the estimated trend in hake abundance and biomass in GSA 11 by SGMED. As shown below both biomass in 2008 and the abundance in the last years a high level of uncertainty is clear.

The estimated abundance and biomass indices since 1999 show high variation without any trend.



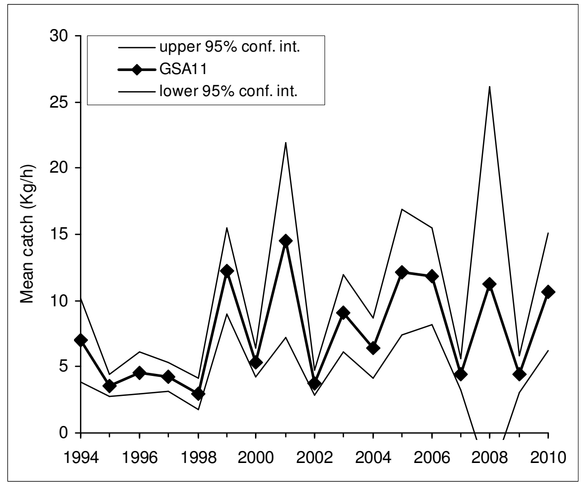


Fig. 6.4.3.1.3.1. Abundance and biomass indices of hake in GSA 11.

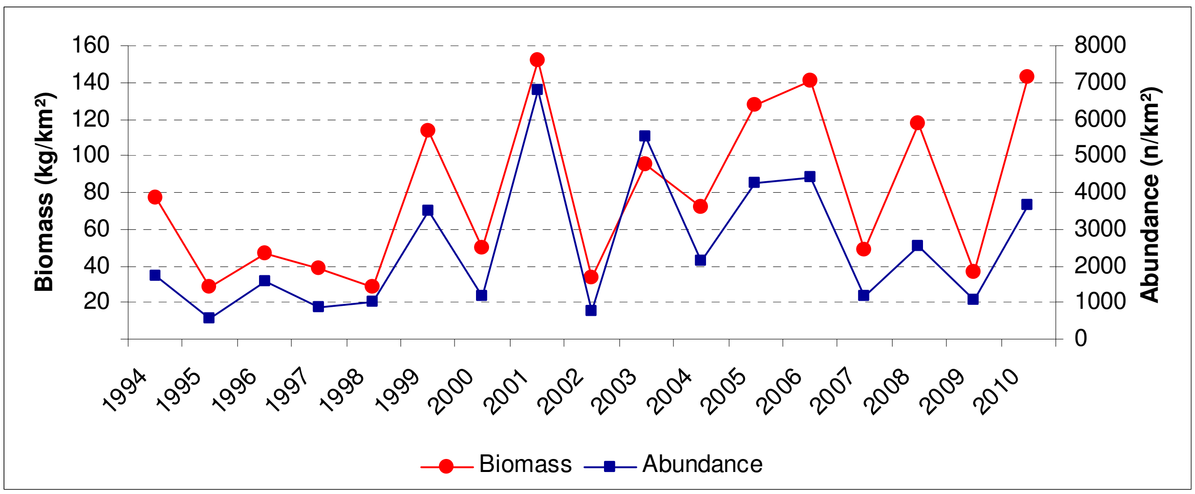


Fig. 6.4.3.1.3.2. Abundance and biomass indices of hake in GSA 11.

6.4.3.1.4 Trends in abundance by length or age

The following figures 6.4.3.1.4.1 and 6.4.3.1.4.2 display the stratified abundance indices of GSA 11 in 1994-2001 and 2002-2010 respectively.

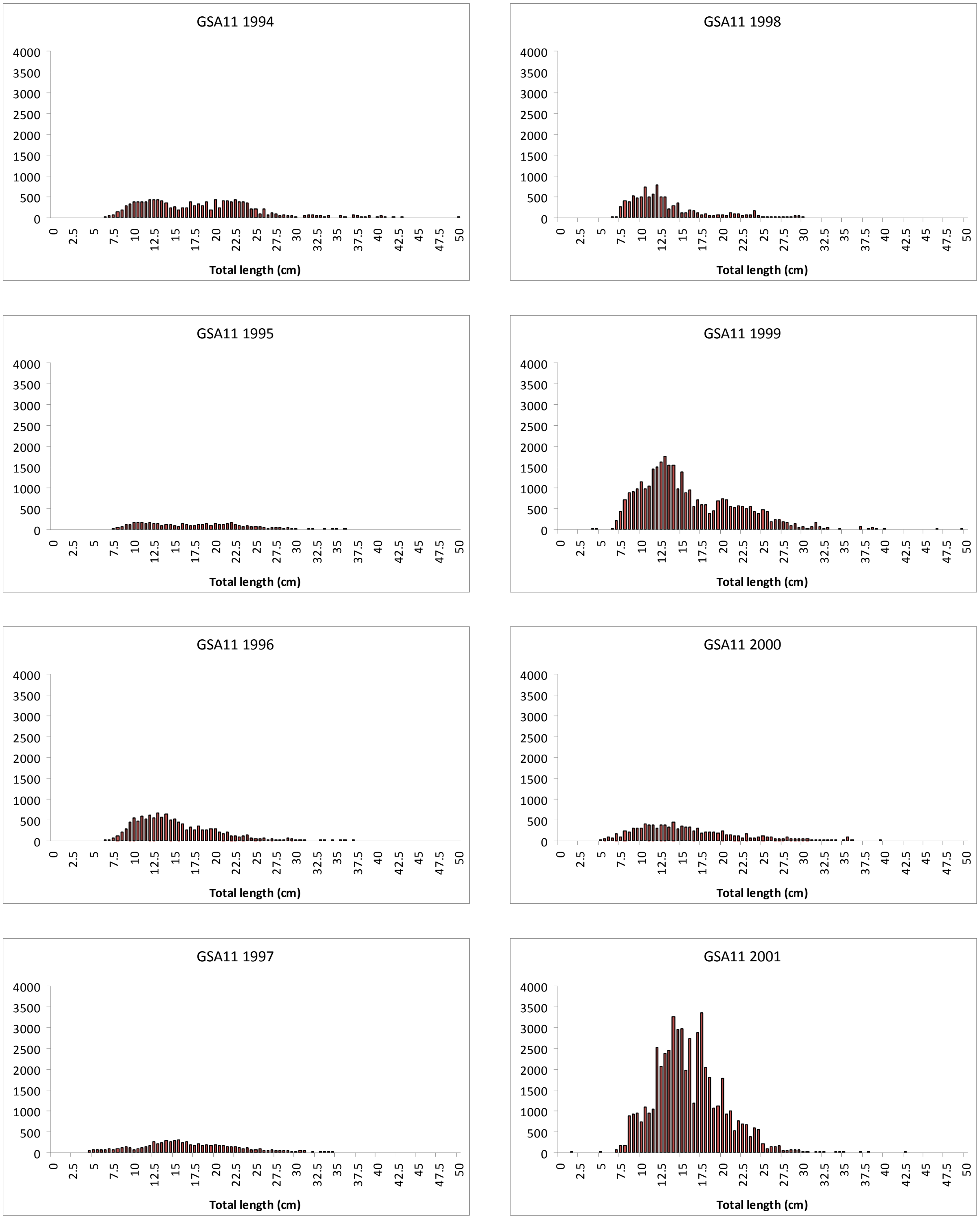
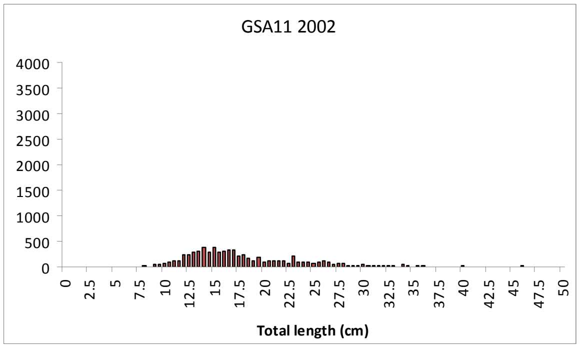
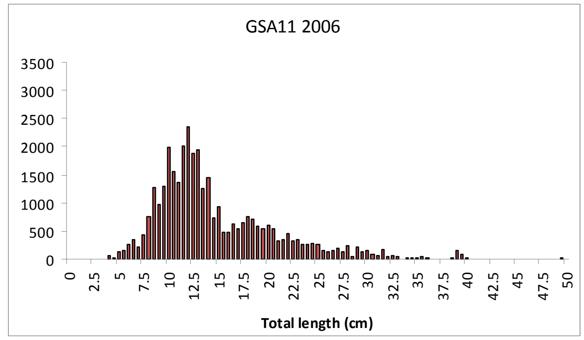


Fig. 6.4.3.1.4.1. Stratified abundance indices by size, 1994-2001.


GSA11 2002
0
500
1000
1500
2000
2500
3000
3500
4000
0
2.5
5
7.5
10
12.5
15
17.5
20
22.5
25
27.5
30
32.5
35
37.5
40
42.5
45
47.5
50
Total length (cm)


GSA11 2006
0
500
1000
1500
2000
2500
3000
3500
0
2.5
5
7.5
10
12.5
15
17.5
20
22.5
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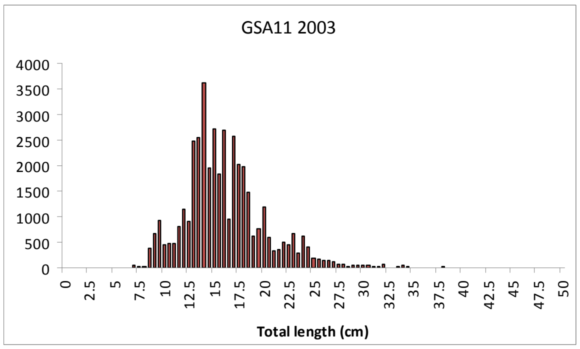
27.5
30
32.5
35
37.5
40
42.5
45
47.5
50
Total length (cm)


GSA11 2003
0
500
1000
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2000
2500
3000
3500
4000
0
2.5
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7.5
10
12.5
15
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22.5
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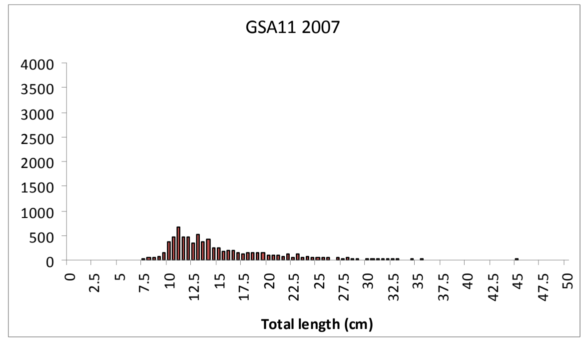
37.5
40
42.5
45
47.5
50
Total length (cm)


GSA11 2007
0
500
1000
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2000
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3000
3500
4000
0
2.5
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7.5
10
12.5
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17.5
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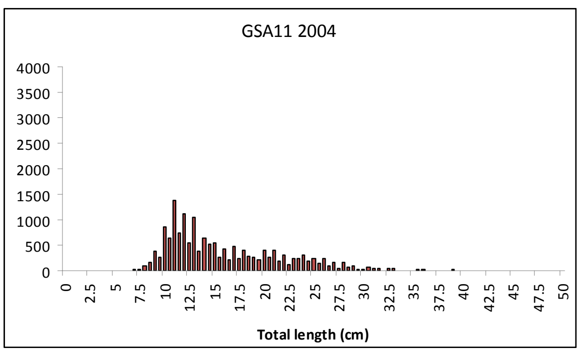
37.5
40
42.5
45
47.5
50
Total length (cm)


GSA11 2004
0
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1000
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2000
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2.5
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10
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37.5
40
42.5
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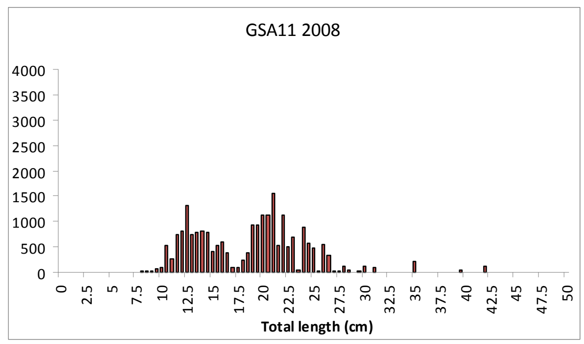
47.5
50
Total length (cm)


GSA11 2008
0
500
1000
1500
2000
2500
3000
3500
4000
0
2.5
5
7.5
10
12.5
15
17.5
20
22.5
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27.5
30
32.5
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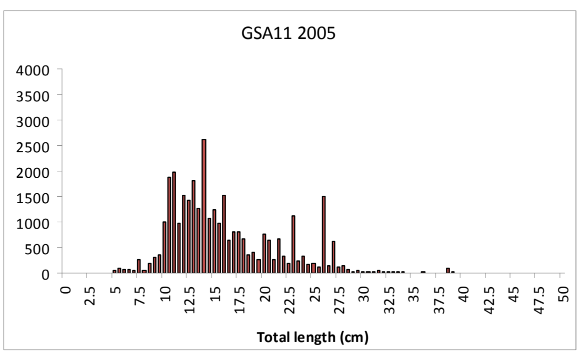
37.5
40
42.5
45
47.5
50
Total length (cm)


GSA11 2005
0
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1000
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2000
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3500
4000
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2.5
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7.5
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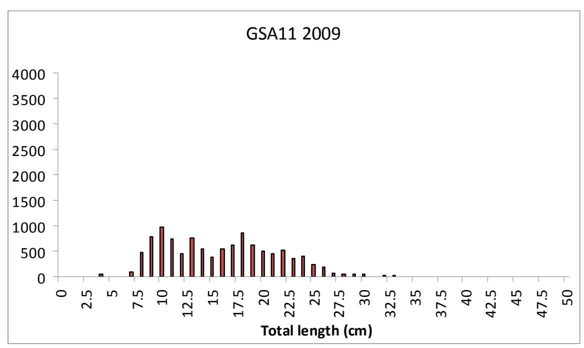
47.5
50
Total length (cm)


GSA11 2009
0
500
1000
1500
2000
2500
3000
3500
4000
0
2.5
5
7.5
10
12.5
15
17.5
20
22.5
25
27.5
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32.5
35
37.5
40
42.5
45
47.5
50
Total length (cm)

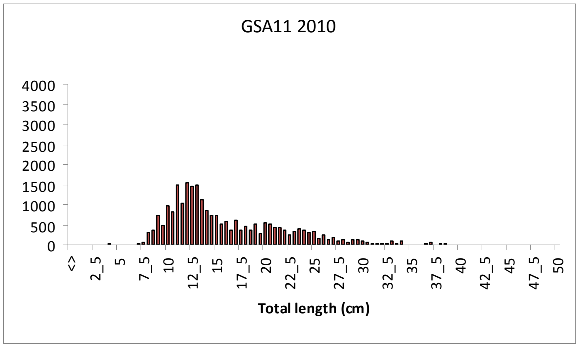


Fig. 6.4.3.1.4.2. Stratified abundance indices by size, 2002-2010.

6.4.3.1.5 Trends in growth

No analyses were conducted.

6.4.3.1.6 Trends in maturity

No analyses were conducted.

6.4.4 Assessment of historic stock parameters

6.4.4.1 Method 1: SURBA

6.4.4.1.1 Justification

The MEDITS survey provided the longer standardized time-series data on abundance and population structure of *M. merluccius* in the GSA11 which allows utilizing the SURBA software for the assessment. The SURBA assessment tool reconstructs the evolution of F from length frequency distribution (LFD).

The SURBA was applied to the MEDITS survey estimates.

6.4.4.1.2 Input parameters

Data from trawl surveys (time series of MEDITS from 1994 to 2010) and effort and landings data from DCR have been used for the analysis. The SURBA software package (Needle, 2003) use trawl surveys data available from MEDITS to reconstruct trend in population structure and fishing mortality of hake in GSA 11.

The LFDs were converted in numbers at age using the "age slicing" subroutine as implemented in the R program introduced by the working group.

Table 6.4.4.1.2.1. Input data used in the SURBA model.

	Age					
Year	0	1	2	3	4	5+
1994	10484	5080	582	53.247	13.100	0.000
1995	2132	1025	80	3.184	1.447	3.221
1996	11611	2198	77	31.986	12.553	1.748
1997	3323	1510	34	6.920	2.456	0.674
1998	3830	943	32	61.799	0.632	1.000
1999	23292	6401	256	24.268	1.959	0.674
2000	7272	1829	121	14.724	3.710	0.000
2001	41386	9609	116	20.806	1.672	1.439
2002	3017	1390	81	4.159	7.403	0.000
2003	20699	5446	50	3.226	1.388	0.000
2004	9061	2467	53	7.040	2.532	0.000
2005	14003	6504	109	5.814	0.000	0.000
2006	10362	3931	291	69.452	29.062	3.942
2007	5799	1004	99	15.579	2.877	0.674
2008	7669	4516	102	7.884	3.363	0.000
2009	5013	1885	26	7.484	0.718	0.000
2010	13291	4089	123	3.681	0.620	1.000

Age	0	1	2	3	4	5+
Proportion mature	0	0,1	0,9	1,0	1,0	1,0
Mean weights	0,01	0,01	0,07	0,20	0,39	0,63

The VBGF parameters used to split the LFD has not been changed from those used in the previous SGMED and match to a fast growth set as L_{∞}=100,7 cm, K=0.248, t_0= -0.01.

According to the Prodbiom approach developed by Caddy and Abella (1999), a vectorial natural mortality at age was estimated (Table 6.4.4.1.2.2). Guess-estimates of catchability by age are also given in Table 6.4.4.1.2.2.

Table 6.4.4.1.2.2. Input parameters used in the SURBA analysis (sex combined) in GSA11.

Growth parameters		
Linf	100.7	cm total length
K	0.248	
t_0	-0.01	
Natural mortality		
M vector		Age_0=1.11,Age_1=0.51,Age_2=0.39,Age_3=0.33,Age_4=0.31,Age_{5+}=0.29
Length at maturity		
L50	36	cm total length (sex combined)
Catchability (q)		q_0=0.8,q_{1-3}=1.0,q_4=0.75,q_{5+}=0.6

6.4.4.1.3 Results

The fitted year effect show high fluctuations in the whole time series. Moreover an increasing trend could be observed since 2005 (Figure 6.4.4.1.3.1). The age effect show a trend decreasing patter with high values for stock mortality at age 1 and 2. The Fitted cohort effects are slight increasing from 1998.

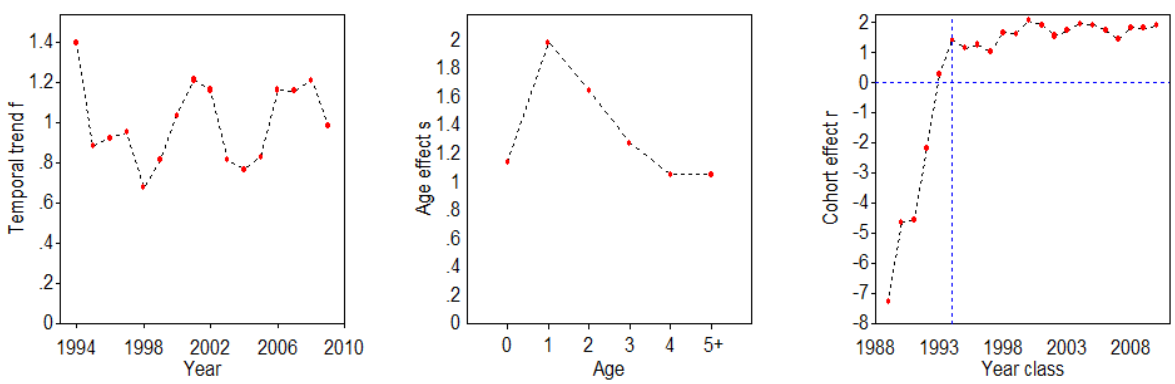


Fig. 6.4.4.1.3.1. MEDITS survey. Fitted year, age and cohort effects estimated by SURBA.

As shown in Fig. 6.4.4.1.3.2 relative indices of spawning stock biomass (SSB) showed a peak in 1994, 2000 and 2006, with a clear drop in the last years. Relative indices estimated by SURBA indicated very high fluctuations of recruitment in the period 1994-2010, with large recruitment observed in 2001, 2003 and 2005.

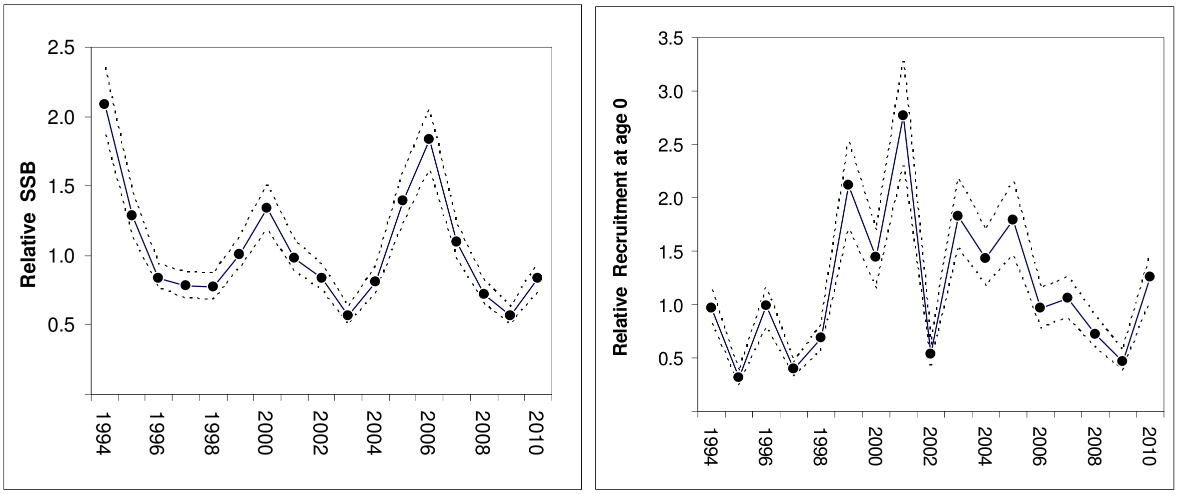


Fig. 6.4.4.1.3.2. Relative SSB, relative recruitment index at age 0 and estimated trend in F_{1-3} of *M. merluccius* in the GSA11. Dotted lines are 2.5% and 97.5% confidence intervals.

Average fishing mortality (F_{1-3}) estimated from trawl survey data (MEDITS) range between 1.22 and 2.46 with a mean value of 1.61 (Figure 6.4.4.1.3.3). These SURBA results also show that the mean F for ages 1-3 was high and increasing up to the maximum value in the last year.

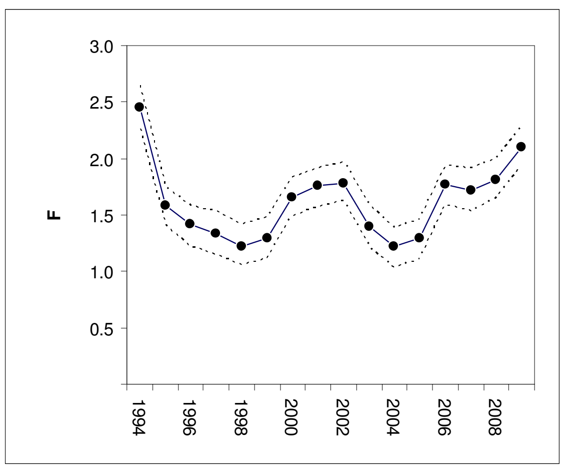
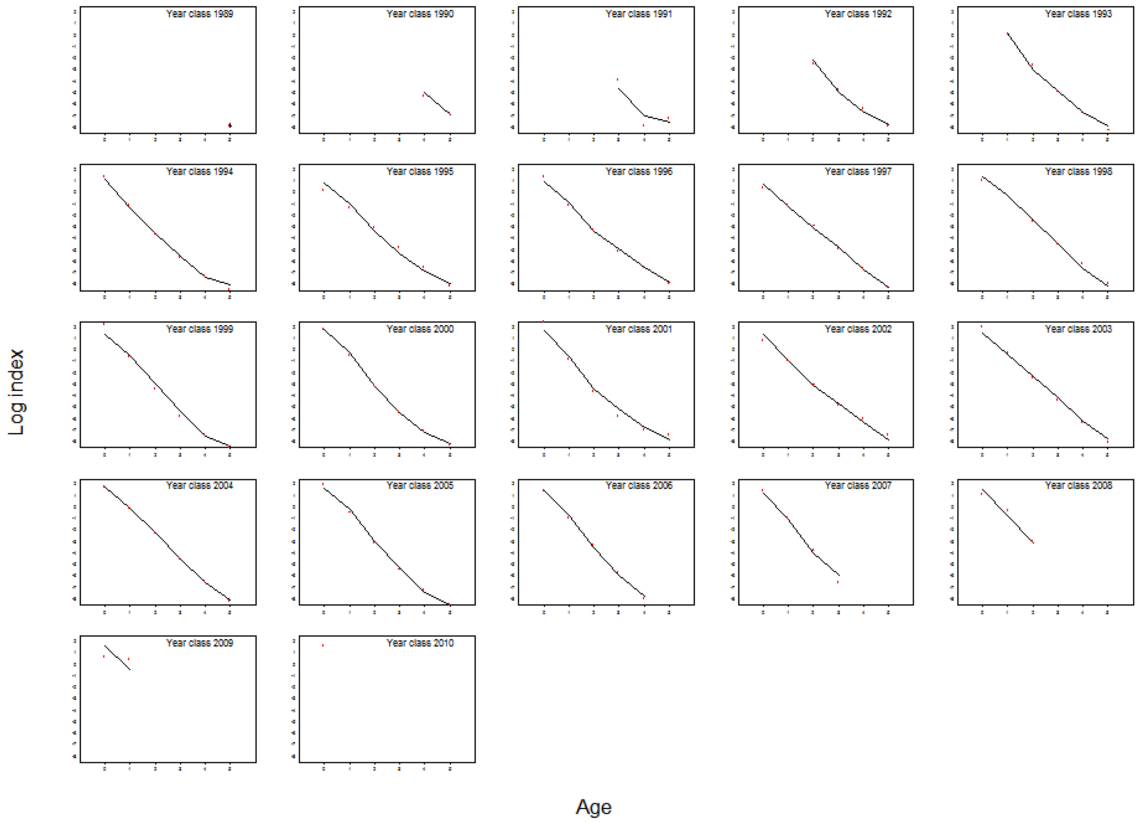


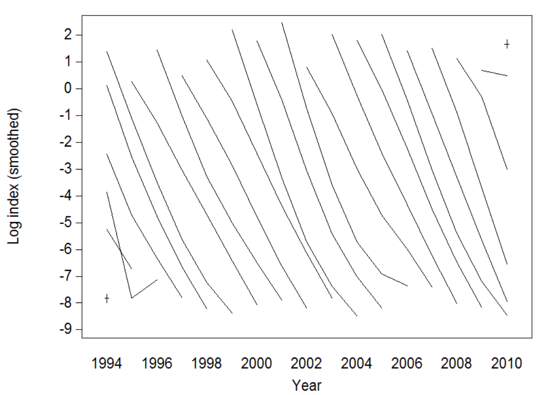
Fig. 6.4.4.1.3.3. Estimated trend in F_{1-3} of *M. merluccius* in the GSA11. Dotted lines are 2.5% and 97.5% confidence intervals.

Model diagnostics

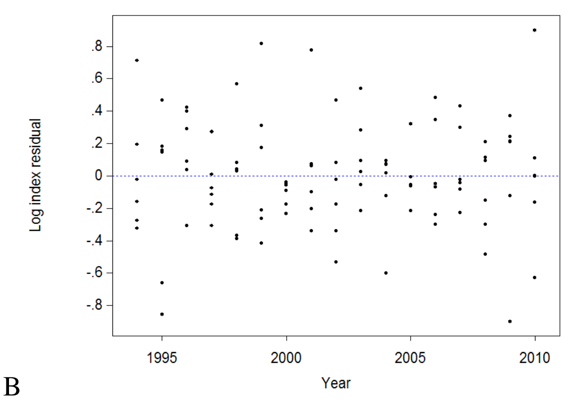
The SURBA model for *M. merluccius* fits well on survey data and can be considered aceptable to sustain the analysis. The diagnostic do not highlight trends in the residuals as showed by comparison between observed and fitted abundance indices per year, comparative scatterplot at age, catch curves and residual of the log index abundance (Figure 6.4.4.1.3.4).


Year class 1989
Year class 1990
Year class 1991
Year class 1992
Year class 1993
Year class 1994
Year class 1995
Year class 1996
Year class 1997
Year class 1998
Year class 1999
Year class 2000
Year class 2001
Year class 2002
Year class 2003
Year class 2004
Year class 2005
Year class 2006
Year class 2007
Year class 2008
Year class 2009
Year class 2010
Log index
Age

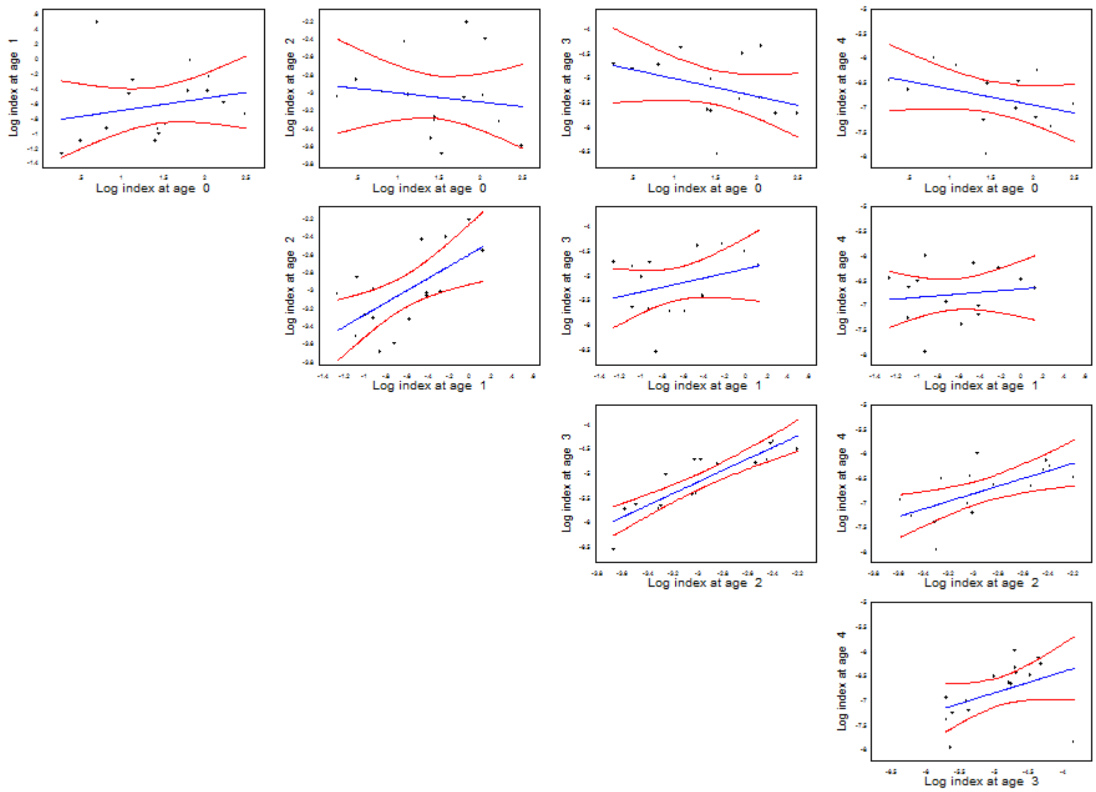
A


Log index (smoothed)
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year

B


Log index residual
.8
.6
.4
.2
0
-.2
-.4
-.6
-.8
1995
2000
2005
2010
Year

C



D

Fig. 6.4.4.1.3.4. Model diagnostic for SURBA model in the GSA 11 (MEDITS survey). A) Comparison between observed (points) and fitted (lines) survey abundance indices, for each year; B) Log survey abundance indices by cohort. Each line represents the log index abundance of a particular cohort throughout its life; C) Log index residuals over time and D) Comparative scatterplots at age.

6.4.4.2 Method 2: LCA

6.4.4.2.1 Justification

This LCA assessment of hake in the GSA 11 was performed aimed at the estimation of a vector of F at size, using official data on total annual catches by size.

Because of the data quality constrains a pseudo-cohort analysis was preferred to a formal VPA. Actually VIT was carried out applying to 3 years of landing data (2006,2009 and 2010) only, i.e. when discard information were available.

6.4.4.2.2 Input parameters

Data coming from DCR provided at STECF EWG 11-20 contained information on hake landings and the respective size structure for 2005-10 (Figure 6.4.4.2.2.1).

From this data set the 3 years were used to run an LCA analysis using the VIT software are shown here below (Table 6.4.4.2.2.1, Figure 6.4.4.2.2.2).

The same M vector used for SURBA, was utilized.

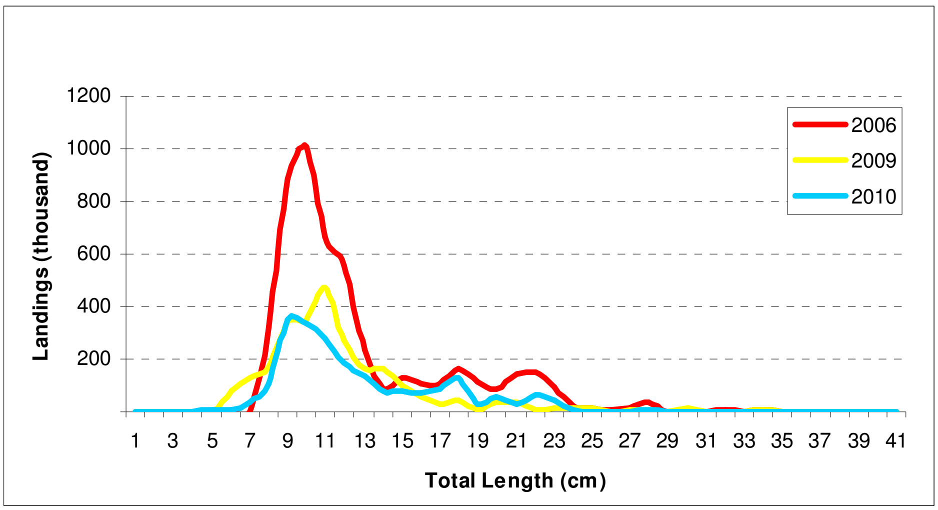
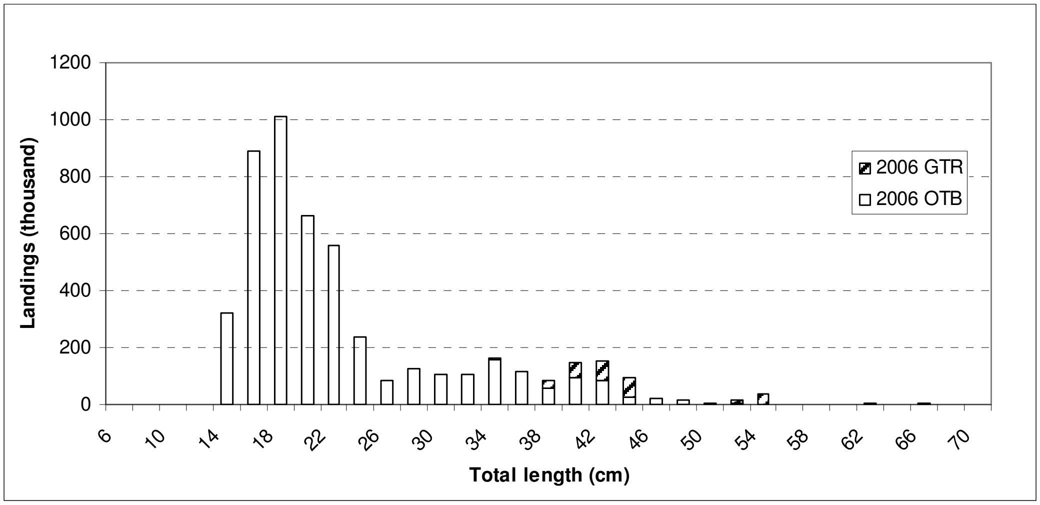


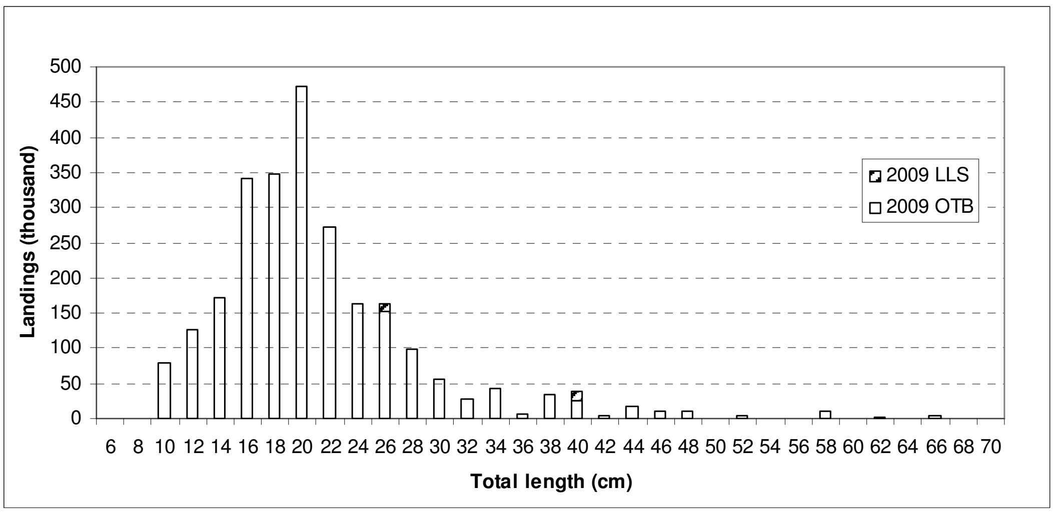
Figure 6.4.4.2.2.1. Length frequency distributions of the landings by year available to EWG 11-12.

Table 6.1.4.2.2.1. Input data for LCA of hake in GSA11 (sex combined, 2006,2009,2010).

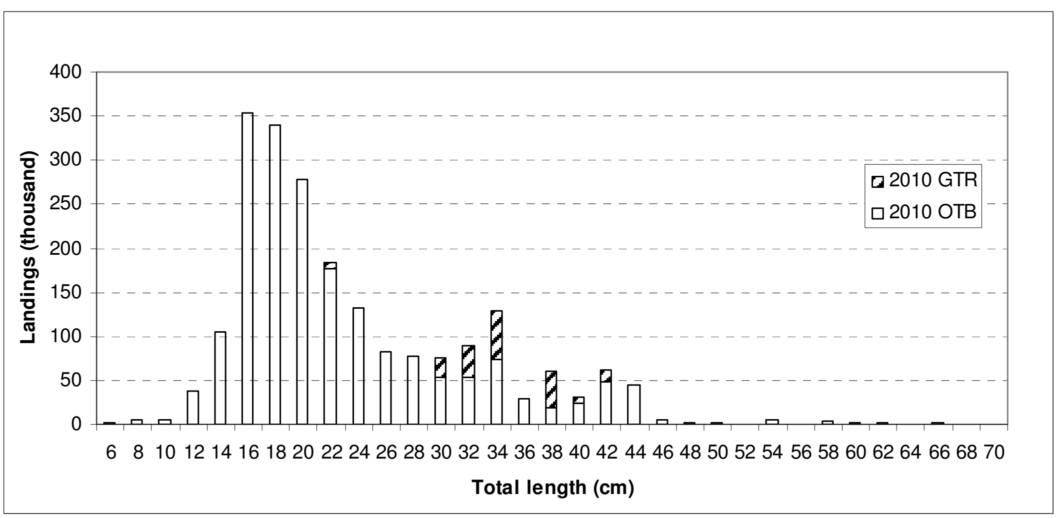
GEAR	OTB	OTB	OTB	GTR	LLS	GTR
TL (cm)	2006	2009	2010	2006	2009	2010
6	0	0	2	0	0	0
8	0	0	5	0	0	0
10	0	79	5	0	0	0
12	0	127	37	0	0	0
14	319	171	105	0	0	0
16	888	341	353	0	0	0
18	1010	348	339	0	0	0
20	662	473	278	0	0	0
22	556	272	178	0	0	7
24	239	163	133	0	0	0
26	85	152	82	0	12	0
28	127	100	78	0	0	0
30	106	55	54	0	0	21
32	107	28	54	0	0	35
34	155	44	73	10	0	56
36	116	6	29	0	0	0
38	57	34	19	29	0	42
40	97	27	25	49	12	7
42	84	4	48	68	0	14
44	27	16	45	68	0	0
46	20	11	4	0	0	0
48	14	11	2	0	0	0
50	7	0	2	0	0	0
52	7	4	0	10	0	0
54	0	0	5	39	0	0
56	0	0	0	0	0	0
58	0	11	3	0	0	0
60	0	0	2	0	0	0
62	7	3	2	0	0	0
64	0	0	0	0	0	0
66	7	4	2	0	0	0
68	0	0	0	0	0	0
70	0	0	0	0	0	0



A



B



C

Fig. 6.4.4.2.2.2. Length frequency distributions of the landings of *M. merluccius* by gear in GSA11 (2006, 2009, 2010).

6.4.4.2.3 Results

Hake landings in the time series considered were concentrated on age classes 0-2 and the estimated fishing mortality peaked for specimens of age class 1 (Table 6.4.4.2.3.1, Figure 6.4.4.2.3.1).

$F_{0.1}$ was 0.27. $F_{0\text{-}2}$ was 0.56 while $F_{1\text{-}2}$ was 0.68.

Table 6.4.4.2.3.1. Fbar by years for *M. merluccius* in the GSA11.

age	Total F 06	Total F 09	Total F10	mean 06-09-10
0	0.29	0.37	0.33	**0.33**
1	0.58	0.82	0.98	**0.79**
2	0.65	0.29	0.75	**0.56**
3	0.18	0.09	0.12	**0.13**
4	0.04	0.04	0.04	**0.04**
Mean F	0.35	0.32	0.45	**0.37**

year	2006	2009	2010	mean 06-09-10
$F_{(0\text{-}2)}$	0.51	0.49	0.69	0.56
$F_{(0.1)}$	0.28	0.26	0.27	0.27

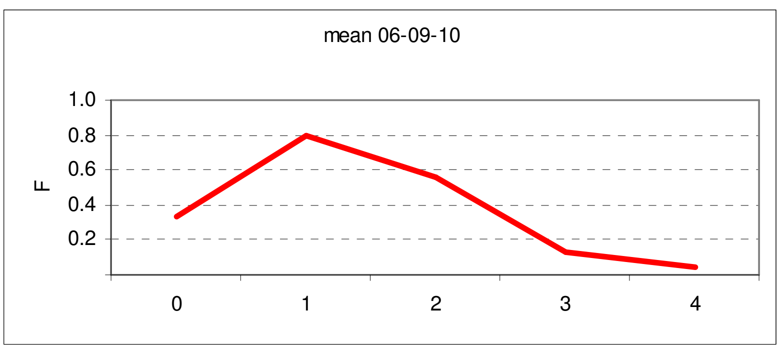


Fig. 6.4.4.2.3.1. LCA output: fishing mortality by ages of *M. merluccius* in the GSA11.

Assuming no variation in the exploitation pattern, the main results of the Y/R analysis are reported in Tab. 6.4.4.2.3.2.

Table 6.4.4.2.3.2 The main results of the VIT analysis.

Yield (t)	Recruitment (ml)	F	Z
304112	7	0.37	0,94

6.4.5 Long term prediction

For the long term predictions both VIT and YIELD software were used.

6.4.5.1 Method 1: VIT

6.4.5.1.1 Justification

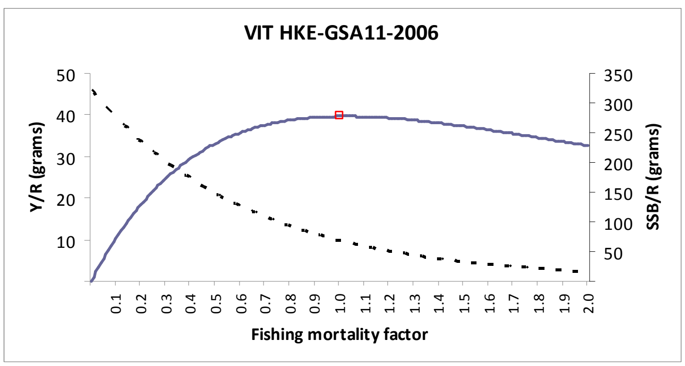
Y/R analyses as implemented in the package VIT4 win (Lleonart and Salat 2000) were used to studying the stock production with increasing exploitation under equilibrium conditions.

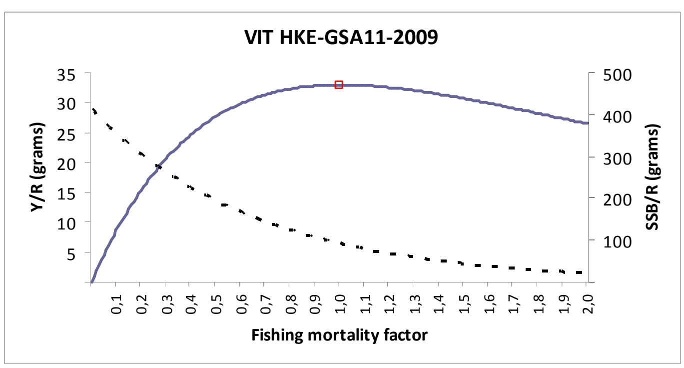
6.4.5.1.2 Input parameters

Input parameters are given in section XX on the VIT assessment above. Landing data come from DCF call for GSA 11.

6.4.5.1.3 Results

The VIT results regarding the long term prediction are presented below (Figure 6.4.5.1.3.1).





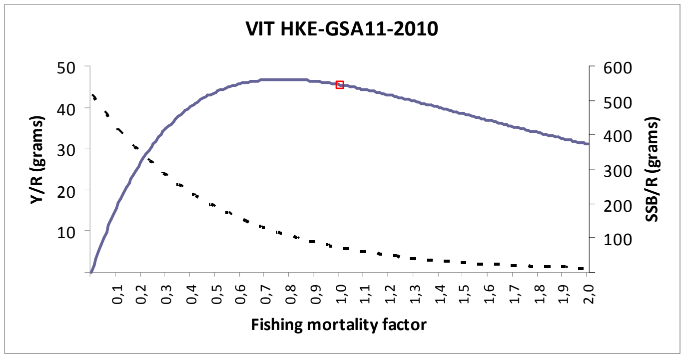


Fig. 6.4.5.1.3.1. Spawning Stock Biomass (SSB) and Yield (Y) per recruit by different level of F factor (year 2006, 2009 and 2010).

6.4.5.2 Method 2: YIELD

6.4.5.2.1 Justification

One of the greatest sources of uncertainty in fisheries management is the very high year to year variability in recruitment. Including such stock recruitment relationship (SRR) in an analytical YPR model changes its predictions considerably.

The Yield software (Hoggarth *et al.*, 2006), that allows for uncertainty in parameter inputs, was used to estimate $F_{0.1}$ as target equilibrium YPR reference point for the stock assuming some uncertainty in parameters estimations.

6.4.5.2.2 Input parameters

The following parameters used to estimate $F_{0.1}$ through Yield software were reported below (Tab 6.4.5.2.2.1).

Moreover a guess estimate of uncertainty in terms of coefficient of variation was added to each parameter.

Recruitment was derived from the estimated age 0 classes computation by VIT in 2010.

An estimation of F was obtained from Z – M by the Beverton and Holt Z estimator.

Tab. 6.4.5.2.2.1. Input to long term forecast.

$L\infty$ = 100.7 cm total length
K = 0.248
t_0 = -0.01
a = 0.004
b = 3.156
M = 0.48 CV=0.005
L_{50} = 36 cm, normally distributed CV=0.05
Lc100 = 10 cm, normally distributed CV=0.05
Spawning season: January-December
Fishing season: January-December
Stock-recruit relationship (SRR) constant recruitment 7 million CV=0.2; uncertainty in R0=0.1

6.4.5.2.3 Results

The probability distribution of $F_{0.1}$ (1000 simulations) was shown in the figure 6.4.5.2.3.1. Uncertainty in model parameters produced considerable variations in $F_{0.1}$ which ranged between 0.2 and 0.28 ($F_{0.1}$mean = 0.23).

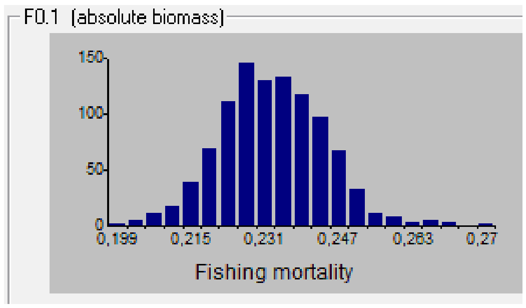


Fig. 6.4.5.2.3.1. Probability distribution of $F_{0.1}$ obtained using the Yield software.

According to these calculations, F_{curr} (0.37 from VIT) was above the average (0.23) and the maximum (0.28) estimated $F_{0.1}$ values.

$F_{0.1}$ was assumed as target reference point. F_{ref} were considered as limit reference points. F_{ref} is the F where the ratio SSB/initial SSB is equal to 0.30. The following mean values were obtained: $F_{0.1}$= 0.23 and F_{ref} = 0.37.

6.4.6 Data quality

MEDITS survey data were available from 1994 to 2010, while 2011 is missing as for the other Italian GSAs. STECF noted that landing and discard seems to be misreported in some years. In particular landings at length for GTR are not reported in 2007 and 2009, while for LLS are only reported in 2009. Even if the contribution to total landings of these fisheries (GTR and LLS) is not high in the GSA11, it is not clear to EGW 11-20 if they are or not belonging to a real fishery for hake.

Furthermore, like in other italian GSAs, discards were only reported for OTB in 2006, 2009 and 2010, when were mandatory for DCR.

For GTR discards are reported in 2005 and 2010, but data seems to be not reliable neither because the length distribution (discards' lengths range from 27 to 44 cm), nor because is the only SA where have been reported for those gear.

Since the significance of the discards component for the assessment of Hake and because of the incosistences noted above, EWG 11-20 decide to use only 3 years for the analysis (i.e. when discard were reported for OTB).

6.4.7 Scientific advice

6.4.7.1 Short term considerations

6.4.7.1.1 State of the spawning stock size

No biomass reference points have been proposed for this stock. As a result, EWG 11-20 is unable to fully evaluate the status of the stock with respect to biomass.

6.4.7.1.2 State of recruitment

No reference points have been proposed.

Relative indices estimated by SURBA indicated very high fluctuations of recruitment in the period 1994-2010, with a clear decreasing trend in the last five years.

6.4.7.1.3 State of exploitation

Both SURBA and VIT showed an overfishing status of hake in GSA 11. Thus, EWG 11-20 recommends that fishing effort should be reduced until fishing mortality is below or at the proposed level F_{MSY}, in order to avoid future loss in stock productivity and landings. To achieve this goal a multi-annual management plan is required.

6.5 Stock assessment of red mullet in GSA 11

6.5.1 Stock identification and biological features

6.5.1.1 Stock Identification

Under a management point of view, in the frame of GFCM, it has been decided, when the lack of any evidence does not allow suggesting an alternative hypothesis, that inside each one of the GSAs boundaries inhabits a single, homogeneous stock that behaves as a single well-mixed and self-perpetuating population. Thus, red mullet (*Mullus barbatus*) in GSA 11 was assumed to be confined within the GSA 11 boundaries. In the GSA 11 red mullet is distributed between 0 and 300 m of depth, even though is generally found on shelf bottoms (within 200 m of depths) with the bulk of abundance and biomass up to 100 m. The stock is mainly exploited by the local fishing fleet, using trawl and net gears. Juveniles showed a patchy distribution with some main density hot spots (nurseries) and a high spatio-temporal persistence in western and southern areas.

6.5.1.2 Growth

Analysis of LFDA of red mullet in GSA 11 showed a slow growth pattern both in male and female (SAMED, 2002). For the GSA 11, data from otolith readings (DCR, 2008) show instead a faster growth pattern (sex combined). STECF EWG 11-20 used the same fast growing parameters adopted in SGMED 10-02. Since the species reaches 50% of its total size at 1.5 year, it has been treated as fast growing.

Table 6.5.1.2.1. Growth parameters for red mullet in the GSA 11 used in the analyses.

L_∞ K	29.1 0.41
to	-0.39
L/W a	0.01
L/W b	3.02

6.5.1.3 Maturity

The species reaches massively the sexual maturity at the age of one year. Observations of proportion of mature individuals by size and analysis with the standard procedure show that the bulk of the females spawn at a size of about 10 cm. Data on spawning (DCR 2006 and 2007) confirm that is taking place on spring (April-June), with a peak during late spring (May).

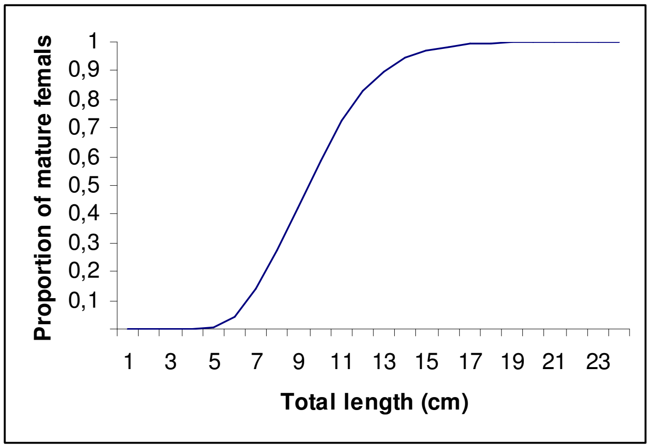


Fig. 6.5.1.3.1. Maturity ogive for females red mullet in GSA 11.

6.5.2 Fisheries

6.5.2.1 General description of fisheries

Red mullet (*Mullus barbatus*) is among the most commercially important species in the area and forms part of an assemblage that is the target of the bottom trawling and small scale fleets, which operate near shore. Particularly, during the bulk of post-recruitment (September-October), small trawlers target this species on shallower waters, near the coasts. From 1994 to 2004, in GSA 11, the trawling-fleet has remarkably changed, with a general increase of the number of vessels and the replacement of the old, low tonnage wooden boats by larger steel boats. For the entire GSA a decrease of 20% for the smaller boats (<30 GRT), which principally exploit this species, was also observed.

6.5.2.2 Management regulations applicable in 2009 and 2010

As in other areas of the Mediterranean, the management of this stock is based on control of fishing capacity (licenses), fishing effort (fishing activity), technical measures (mesh size and area closures), and minimum landing sizes (EC 1967/06). Two small closed areas were also established along the mainland (west and east coast respectively), although these are finalised to protect lobsters mainly. Since 1991, a fishing ban for trawling 45 day was have been almost every year enforced in different periods for the small scale fishery (March, TSL<=15) and for the big trawlers (September, TSL<15). In the following figure, differences in the closure regime are shown; a red point means that no fishing ban measure has been adopted for that particular year.

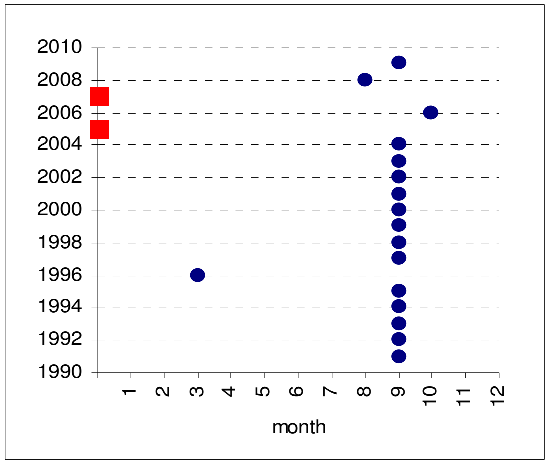


Fig. 6.5.2.2.1. Differences in the closure regime are shown; a red point means that no fishing ban measure has been adopted for that particular year.

Furthermore, recently (2006) the closure was differentiate also considering different coast (west and east mainly) with a shift of 15 days of the fishing ban period. Towed gears are not allowed within three nautical miles from the coast or at depths less than 50 m when this depth is reached at a distance less than 3 miles from the coast.

6.5.2.3 Catches

6.5.2.3.1 Landings

Landings for GSA 11 by major fishing gears are listed in Table 6.5.2.3.1.1. Since 2005, landings increased from 253 t to 346 t in 2007 and decreased to 163 t in 2010 (Figure 6.5.2.3.1.1). Landings are dominated by demersal trawl fisheries (OTB), while trammel net (GTR) have been reported for 2008 only. According to the STECF-EWG 11-20 scientist’s knowledge, DCF data for GSA 11 seems to underestimate landings derived from GTR. Moreover, taking in to account that all the Italian GSAs show a data time series of landings for the GTR, only one year of data for GTR seems unrealistic.

Both a check made by experts of the official data and an update of information are needed to improve and facilitate the work in next SGMED meetings.

Table 6.5.2.3.1.1. Annual landings (in tons) by gear in GSA 11, 2005-2010 as reported through DCF.

GEAR	2005	2006	2007	2008	2009	2010
GTR	0	0	0	0,68	0	0
OTB	253	249	346	263	222	163
total landings (all gears)	253	249	346	264	222	163

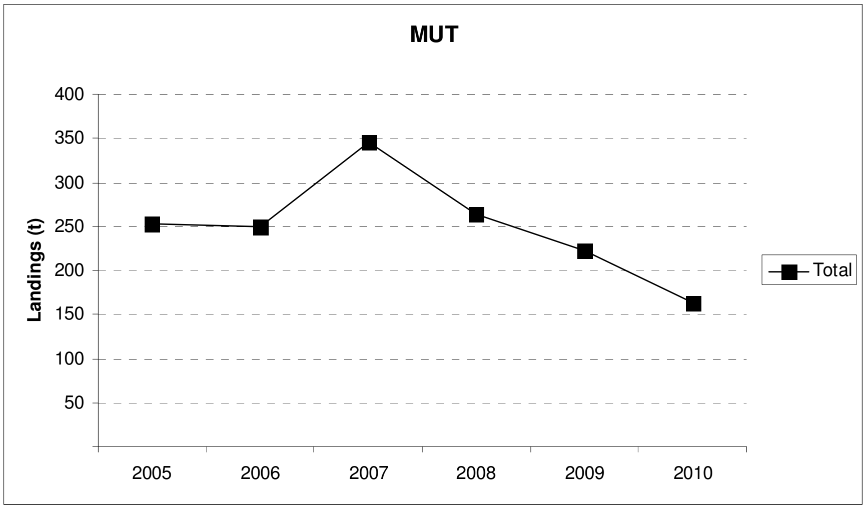


Fig. 6.5.2.3.1.1. Landings (t) by year and major gear types, 2005-2010 as reported through DCR.

6.5.2.3.2 Discards

Discards quantities were reported through DCR for 2006, 2009 and 2010 only.

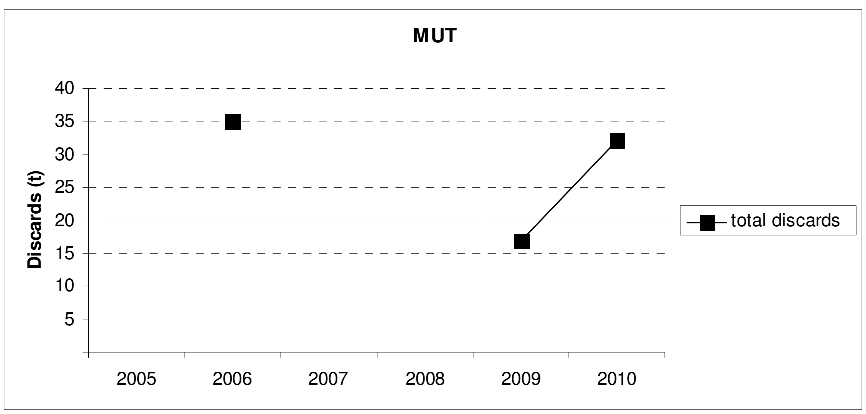


Fig. 6.5.2.3.2.1. Discards (t) by year (2005-2010) as reported through DCR.

Discard at length show the wider range in 2006, while in 2010 the range is smaller and shifted to right.

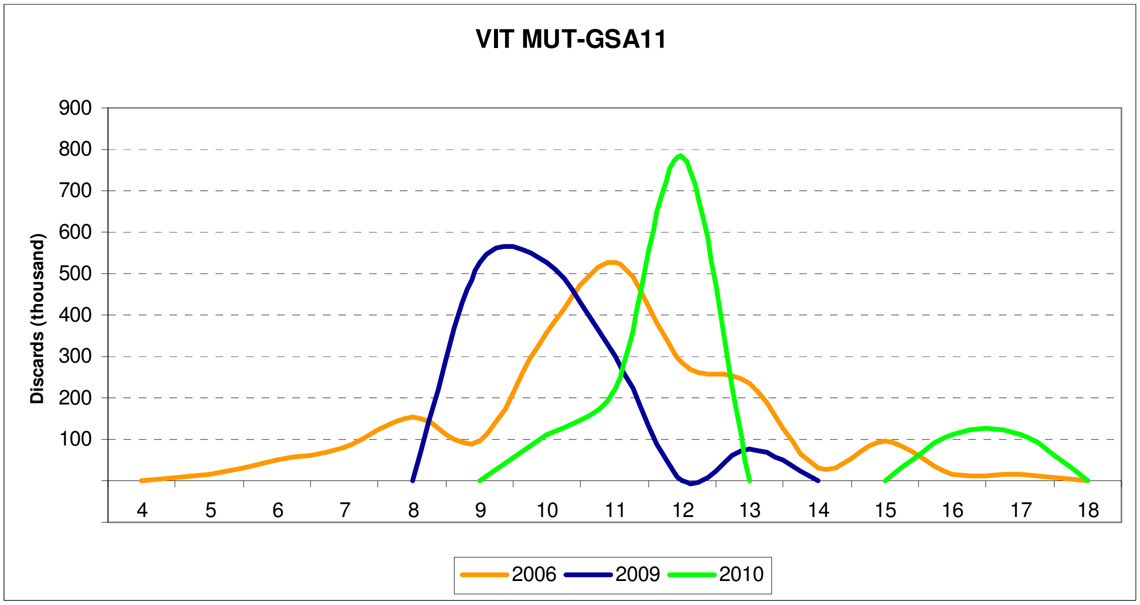


Fig. 6.5.2.3.2.2. Discards at length (thousand) by year (2006, 2009 and 2010) as reported through DCR for OTB.

6.5.2.4 Fishing effort

The reported fishing effort values through the DCF data call was changed and updated for 2010.

Using data available to EGW 11-12, the trends in fishing effort by year and major gear type is listed in Tab. 6.5.2.4.1 and shown in Fig. 6.5.2.4.1 in terms of kW*days. The trend analysis show a major drop of total fishing effort in 2008, when both the trawlers and the small scale fishery effort decrease (of 25 and 31 % respectively). In the last three years the effort was almost stable.

Table 6.5.2.4.1. Trend in fishing effort (kW*days) for Italy in GSA 11 for the major gear types in 2004-2010.

GEAR	2004	2005	2006	2007	2008	2009	2010
FPO	42030	77070	960931	1497019	921315	1039432	999287
FYK				1140			
GNS	1157504	1065868	204874	777750	453491	979982	558828
GTR	6584427	7186648	7227466	4932023	3719222	4103101	4333105
LHP							
LLD	118760	280487	468325	1311593	927405	514982	647982
LLS	1048740	941723	1329827	1135473	649943	672281	530352
LTL			6689	1744	589	566	
none	18500	786	65516	143525	62994	44038	9193
OTB	7706431	7324728	5752588	5865498	4430174	4375729	4041363
PS	27293						
total	16703685	16877310	16016216	15665765	11165133	11730111	11120110

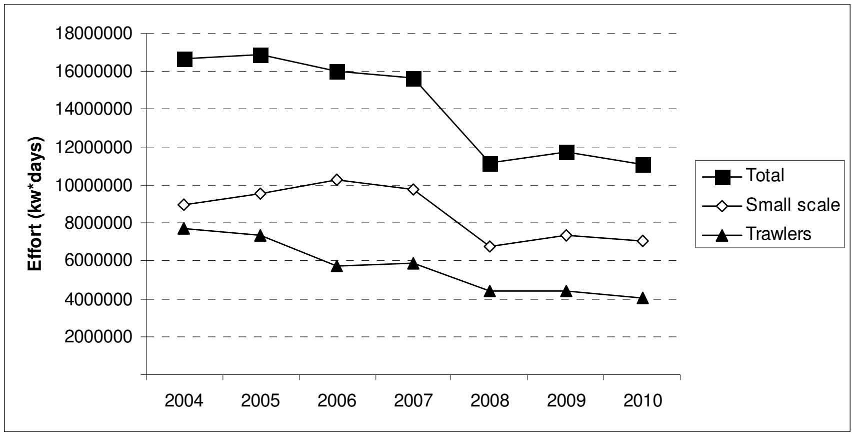


Fig. 6.5.2.4.1. Trend in fishing effort (kW*days) for the Italian fleet in GSA 11 for the major gear types in 2004-2010.

Table 6.5.2.4.2. Trend in fishing effort (kW*days) for Italy in GSA 11 for the major gear types in 2004-2010, as reported through the DCF in 2010.

Gear	Fishery	Vessel_Len	2004	2005	2006	2007	2008	2009	2010
-1	-1	VL1218				18134			
-1	CEP	VL0006				20678	2463		
-1	CEP	VL0612	18500	786	19378	60931	14048	4275	1804
-1	CEP	VL1218			40059	43782	21715	910	
-1	FINF	VL0612			924		24768	38853	7389
-1	FINF	VL1218			5155				
FPO	DEMSP	VL0006				76963	18326	24782	37759
FPO	DEMSP	VL0612	42030	23148	814006	1277817	846628	850868	811483
FPO	DEMSP	VL1218		53922	146925	142239	56361	163782	150045
FYK	DEMSP	VL0006				708	0	0	0
FYK	DEMSP	VL0612				432			
GNS	DEMSP	VL0006			2849	73406	21877	33984	38299
GNS	DEMSP	VL0612	1015513	694933	139688	627676	335747	687764	456896
GNS	DEMSP	VL1218	141991	370935	62337	76668	95867	258234	62966
GNS	SLPF	VL0612							667
GTR	DEMSP	VL0006			177826	113777	82800	75882	75278
GTR	DEMSP	VL0612	5143105	5481274	5787359	3778447	2795301	3228203	3353364
GTR	DEMSP	VL1218	1441322	1705374	1262281	1039799	841121	799016	904463
LLD	LPF	VL0612			114173		6485	6164	16142
LLD	LPF	VL1218	118760	280487	222267	1297228	920920	508818	631840
LLD	LPF	VL2440			131885	14365			
LLS	DEMF	VL0006			11843	17523	2947	3231	0
LLS	DEMF	VL0612	797809	691302	929070	769772	416016	449869	409875
LLS	DEMF	VL1218	250931	250421	297651	324578	230980	219181	120477
LLS	DEMF	VL1824			9933				
LLS	DEMF	VL2440			81330	23600			
LTL	LPF	VL0612			6689	1744	589	566	
OTB	DEMSP	VL0612				1063		152685	193464
OTB	DEMSP	VL1218	1243040	1270821	1475054	134032	1347750	1305105	1176411
OTB	DEMSP	VL1824	55011				829163	700410	571926
OTB	DEMSP	VL2440				19496	259152	218124	138829
OTB	DWSP	VL1218							3769
OTB	DWSP	VL1824							2323
OTB	DWSP	VL2440					139531	199345	270999
OTB	MDDWSP	VL1218				1281844	86074		51154
OTB	MDDWSP	VL1824	2606247	2955031	1870402	1986365	387260	559080	619426
OTB	MDDWSP	VL2440	3802133	3098876	2407132	2442698	1381244	1240980	1013062
PS	SPF	VL1218	27293						
			16703685	16877310	16016216	15665765	11165133	11730111	11120110

6.5.3 Scientific surveys

6.5.3.1 MEDITS

6.5.3.1.1 Methods

Since 1994 the MEDITS trawl surveys have been yearly carried out between May and July (except in 2007).

According to the MEDITS protocol (Relini, 2000; Bertand *et al.*, 2002) a stratified random sampling design with allocation of hauls proportional to depth strata extension (depth strata: 10–50 m, 51–100 m, 101–200 m, 201–500 m, 501–800 m) was adopted. A specific gear (GOC 73, with a 20 mm stretched mesh size in the cod-end) was always used following the instruction stated and reported in Dremière and Fiorentini (1996).

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 11 the following number of hauls was reported per depth stratum (Table 6.5.3.1.1.1).

Table 6.5.3.1.1.1. Number of hauls per year and depth stratum in GSA 11, 1994-2010.

RATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
A11_010-050	16	18	21	21	21	20	19	17	20	18	17	17	19	19	17	18	19
A11_050-100	25	21	22	22	20	22	22	24	19	19	18	21	18	20	19	20	19
A11_100-200	20	23	30	31	31	30	29	30	24	24	24	24	24	24	22	24	24
A11_200-500	33	29	29	26	25	27	24	25	20	24	21	20	20	20	21	19	20
A11_500-800	23	16	21	25	25	24	27	26	16	14	15	14	16	17	16	16	17
al	117	107	123	125	122	123	121	122	99	99	95	96	97	100	95	97	99

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$Yst = \Sigma (Yi*Ai) / A$

$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$

Where:

A=total survey area

Ai=area of the i-th stratum

si=standard deviation of the i-th stratum

ni=number of valid hauls of the i-th stratum

n=number of hauls in the GSA

Yi=mean of the i-th stratum

Yst=stratified mean abundance

V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

6.5.3.1.2 Geographical distribution patterns

The spatial structure of red mullet have been achieved by modelling the spatial correlation structure of the abundance indices through geostatistical techniques, showing clear areas of persistence in the south (Gulf of Cagliari) and western coasts (Carloforte and coast between Bosa Marina and Capo Mannu). Main results and maps are reported in the "nursery section" of SGMED-09-02 report.

6.5.3.1.3 Trends in abundance and biomass

Fishery independent information regarding the state of the red mullet in GSA 11 was derived from the international survey MEDITS. Figure 6.5.3.1.3.1 displays the estimated trend in red mullet abundance and biomass in GSA 11. The estimated abundance and biomass indices do not reveal any significant trends. However, the recent abundance and biomass indices since 2005 appear high but are subject to high uncertainty.

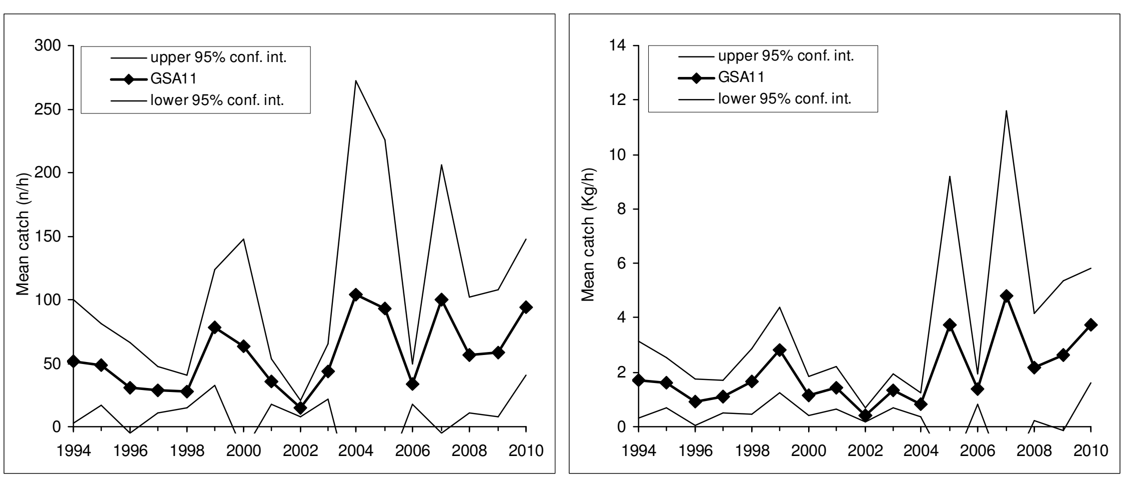


Fig. 6.5.3.1.3.1. Abundance and biomass indices of red mullet in GSA 11.

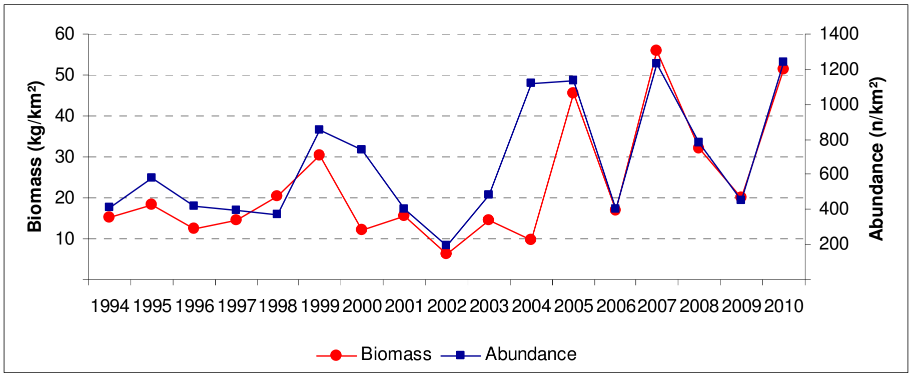
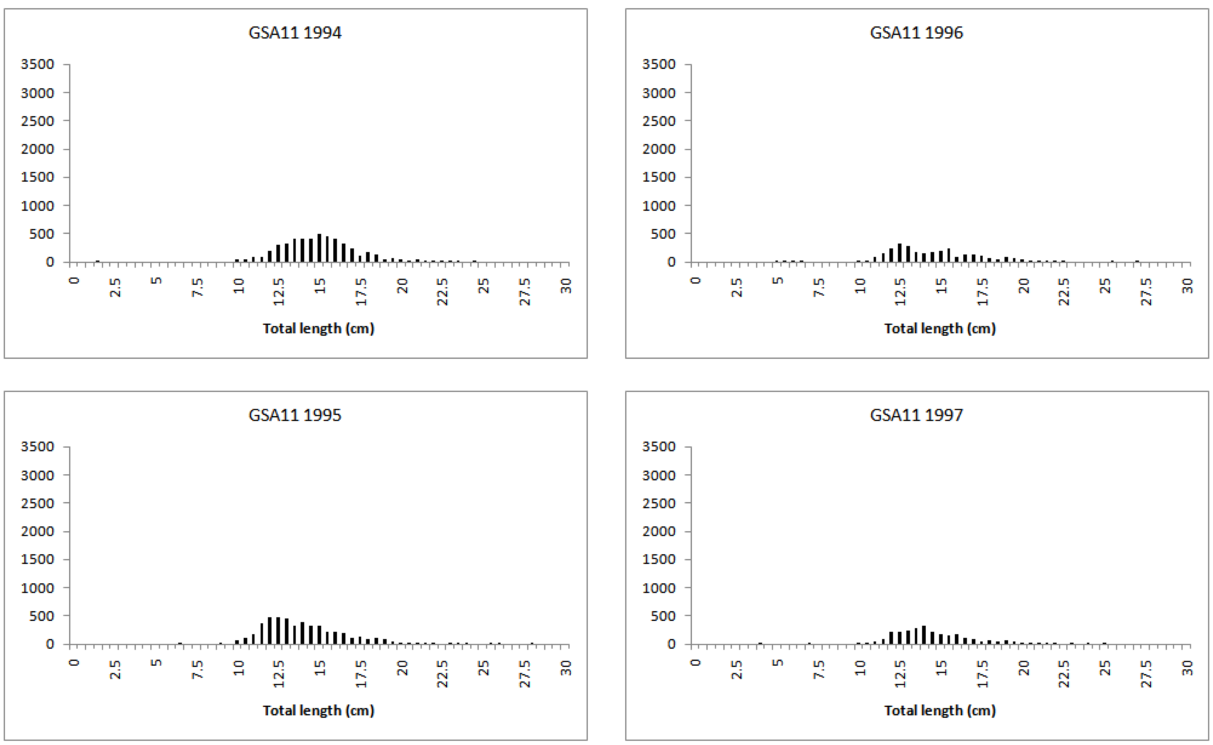


Fig. 6.5.3.1.3.2. Abundance and biomass indices of red mullet in GSA 11.

6.5.3.1.4 Trends in abundance by length or age

The following Figure 6.5.3.1.4.1 and 2 display the stratified abundance indices of GSA 11 in 1994-2001 and 2002-2009.



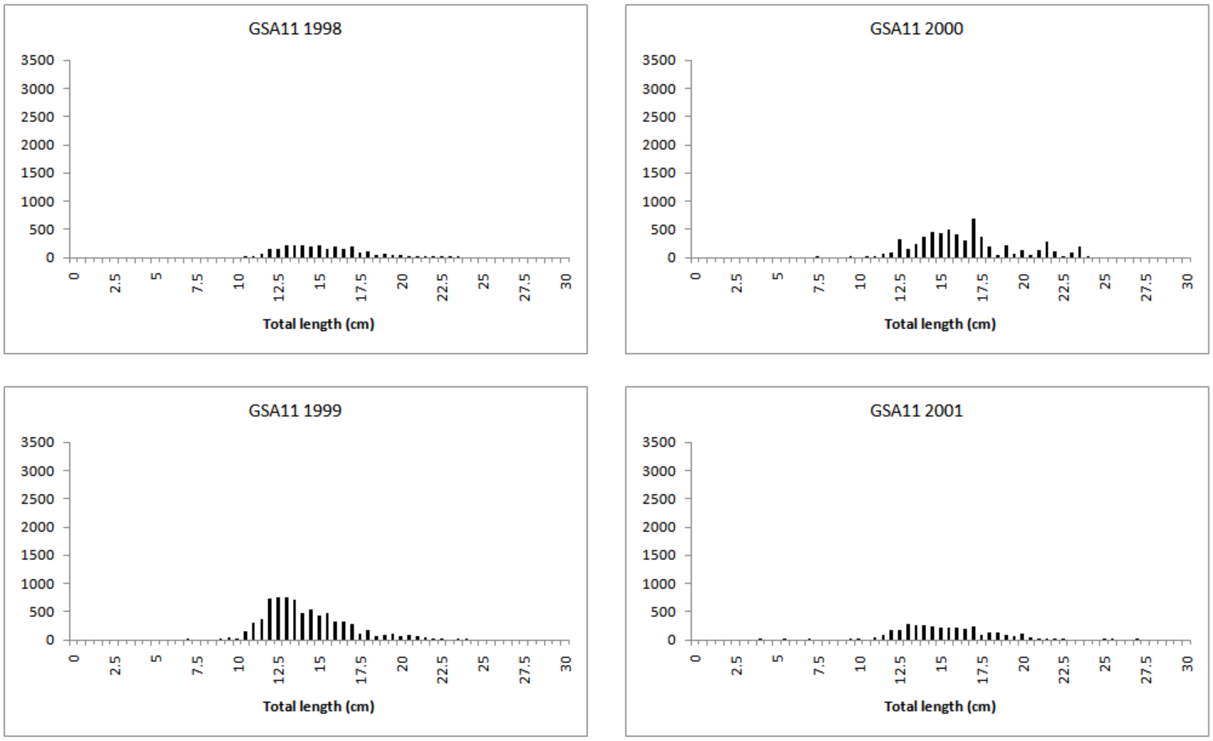
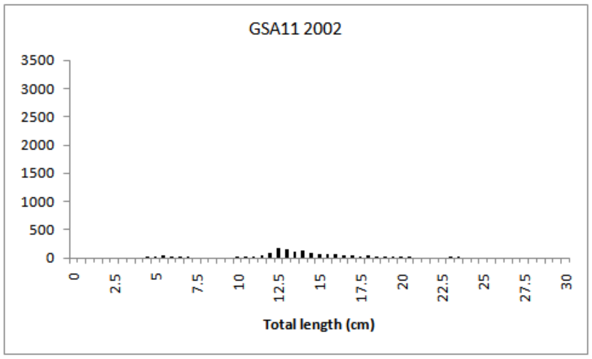
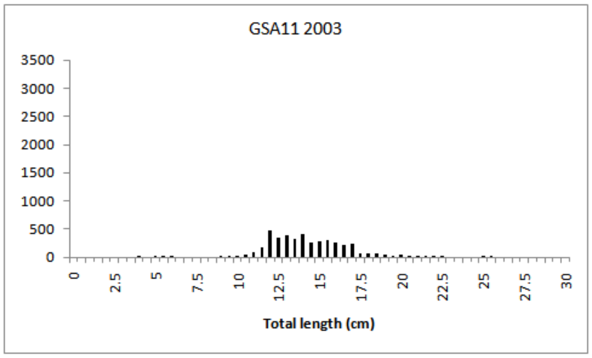
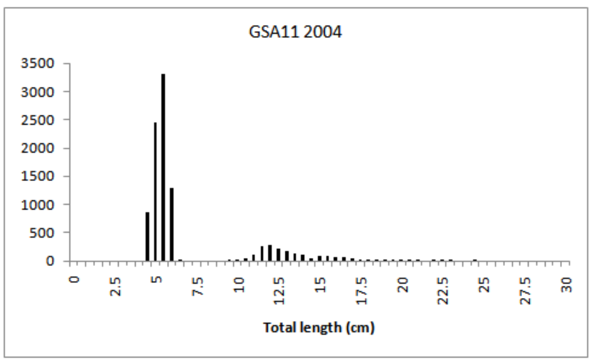
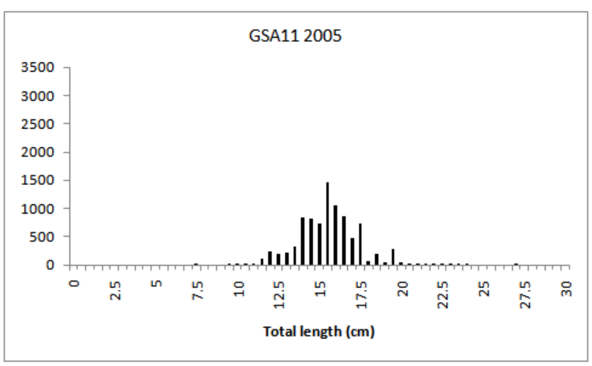


Fig. 6.5.3.1.4.1. Stratified abundance indices by size, 1994-2001.


GSA11 2002
3500
3000
2500
2000
1500
1000
500
0
0
2.5
5
7.5
10
12.5
15
17.5
20
22.5
25
27.5
30
Total length (cm)


GSA11 2003
3500
3000
2500
2000
1500
1000
500
0
0
2.5
5
7.5
10
12.5
15
17.5
20
22.5
25
27.5
30
Total length (cm)


GSA11 2004
3500
3000
2500
2000
1500
1000
500
0
0
2.5
5
7.5
10
12.5
15
17.5
20
22.5
25
27.5
30
Total length (cm)


GSA11 2005
3500
3000
2500
2000
1500
1000
500
0
0
2.5
5
7.5
10
12.5
15
17.5
20
22.5
25
27.5
30
Total length (cm)

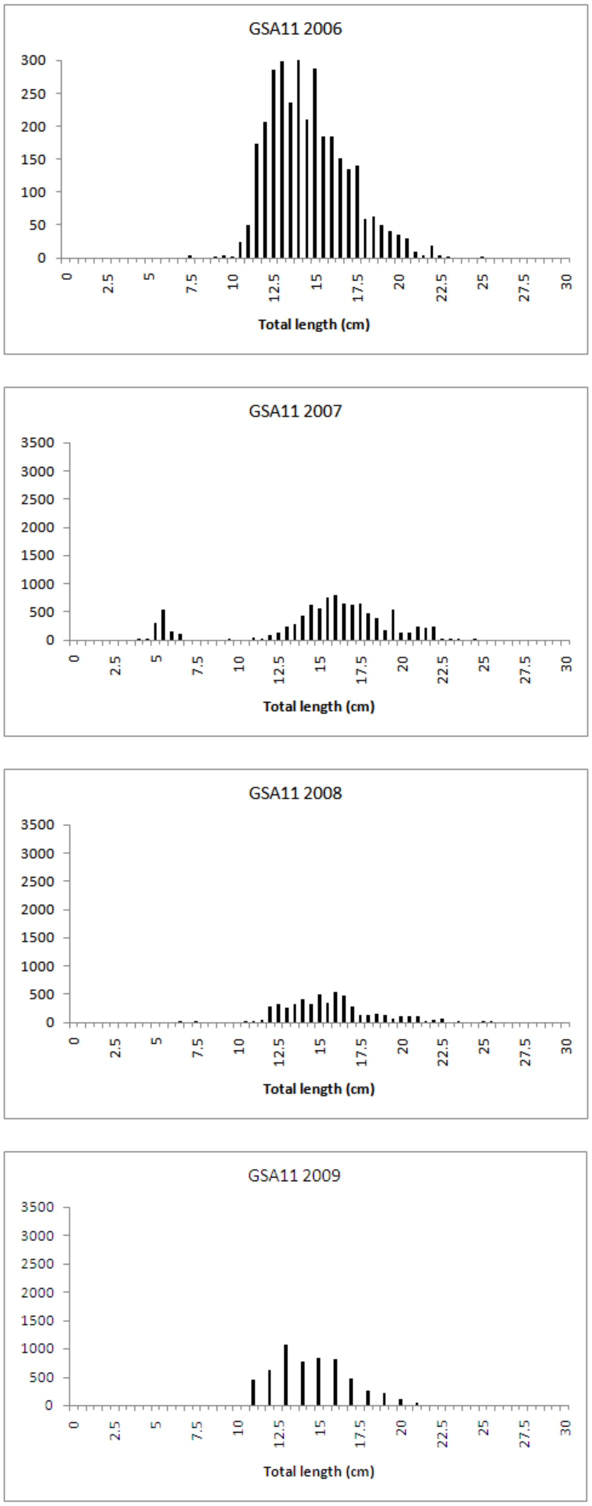


Fig. 6.5.3.1.4.2. Stratified abundance indices by size, 2002-2009.

6.5.3.1.5 Trends in growth

No analyses were conducted.

6.5.3.1.6 Trends in maturity

No analyses were conducted.

6.5.4 Assessment of historic stock parameters

6.5.4.1 Method 1: SURBA

6.5.4.1.1 Justification

The MEDITS survey provided the longer standardized time-series data on abundance and population structure of *M. barbatus* in the GSA11 which allows utilizing the SURBA software for the assessment. The SURBA assessment tool reconstructs the evolution of F from length frequency distribution (LFD).

The SURBA was applied to the MEDITS survey estimates.

6.5.4.1.2 Input parameters

Data from trawl surveys (time series of MEDITS from 1994 to 2010) and landings data from DCR have been used for the analysis. The SURBA software package (Needle, 2003) use trawl surveys data time series available from the MEDITS to estimate fishing mortality rates of red mullet in the GSA 11.

The LFDs were converted in numbers at age using the "age slicing" subroutine as implemented in the R program introduced by the working group.

The VBGF parameters used to split the LFD was the same used for the LCA approach used in SGMED-10-02. According to the Prodbiom approach (Caddy and Abella 1999), a vectorial natural mortality at age was estimated (Table 6.5.4.1.2.1). Guess estimates of catchability at age are given in Table 6.2.4.1.2.1.

Table 6.5.4.1.2.1. Input parameters used in the SURBA analysis (sex combined) in the GSA 11.

VBGF M vector	L_∞=29.1 cm, K=0.41, t_0= -0.39 Age_1=0.41, Age_2=0.27, Age_3=0.24, Age_4=0.21
Catchability (q)	q_{1-4} = 1
Length at maturity (L50)	13 cm (sex combined)

6.5.4.1.3 Results

SURBA output show that the mean F for ages 1-3 was varying until 2001 with a clear decreasing trend thereafter and an increase in 2009 (Figure 6.5.4.1.3.1).

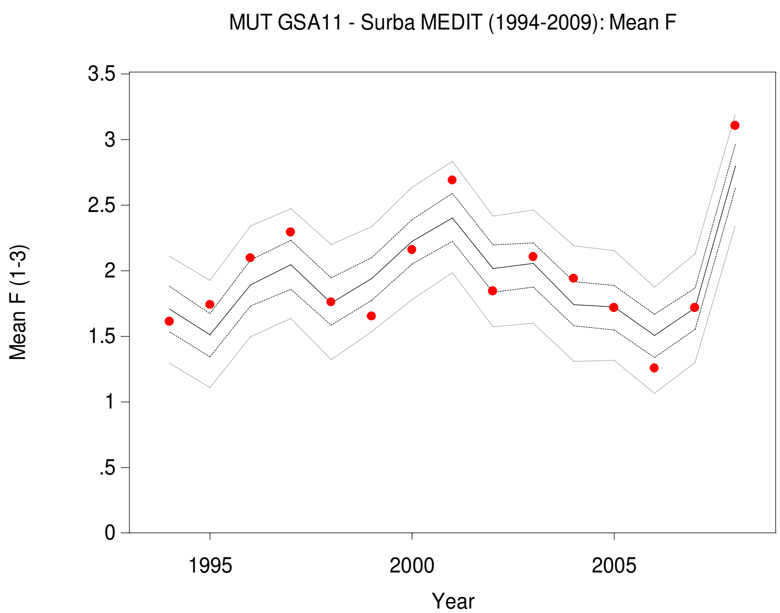


Fig. 6.5.4.1.3.1 Fishing mortalities estimated by SURBA using trawl surveys age composition (MEDITS).

Peaks in relative SSB has been detected in 1999 and 2007, as show below in figure. 6.5.4.1.3.2.

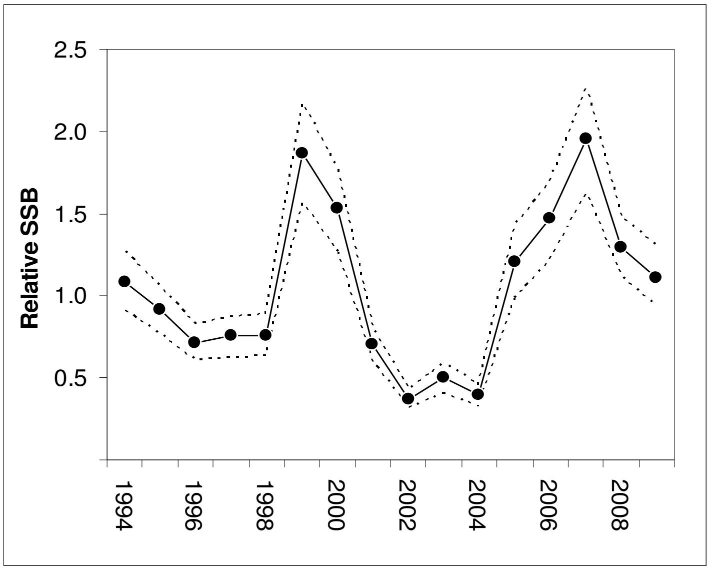
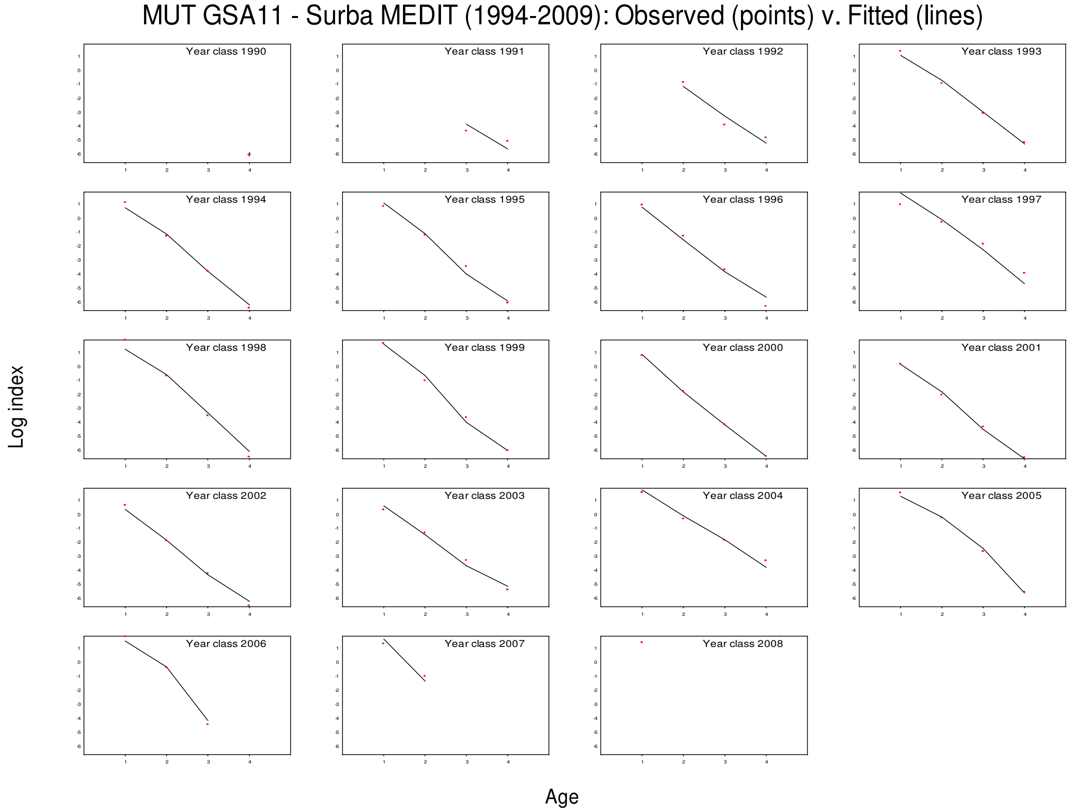


Fig. 6.5.4.1.3.2. Trend of SSB estimated by SURBA using trawl surveys age composition (MEDITS).

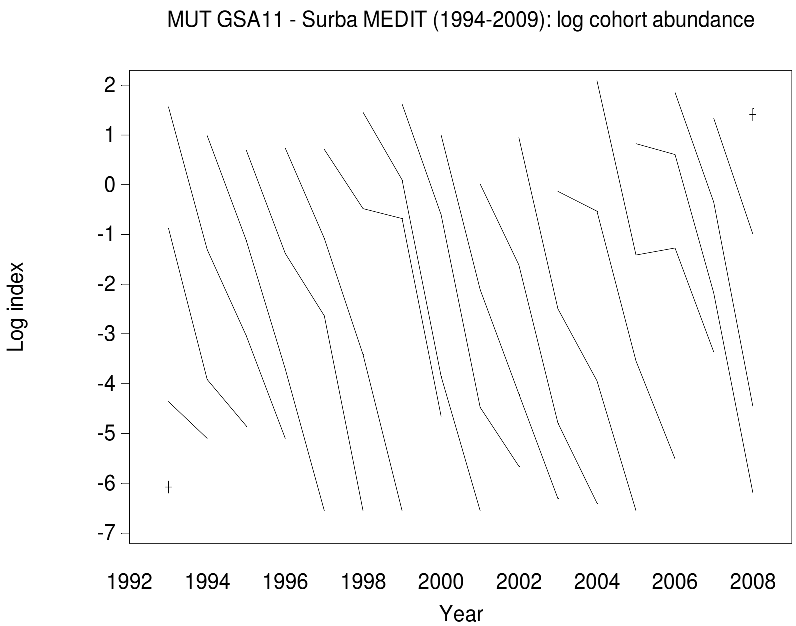
Since the survey period is close to the spawing period, the relative recruitment indices were not shown.

Model diagnostics are presented in figure 6.5.4.1.3.3. Observed and fitted MEDITS survey indices of abundance for each year were reasonably in agreement (A) while catch curve reconstruction from log survey abundance indices showed some deviation from the expected curve (B). Log index residuals over time, plotted by age class (C) varied without any trend.



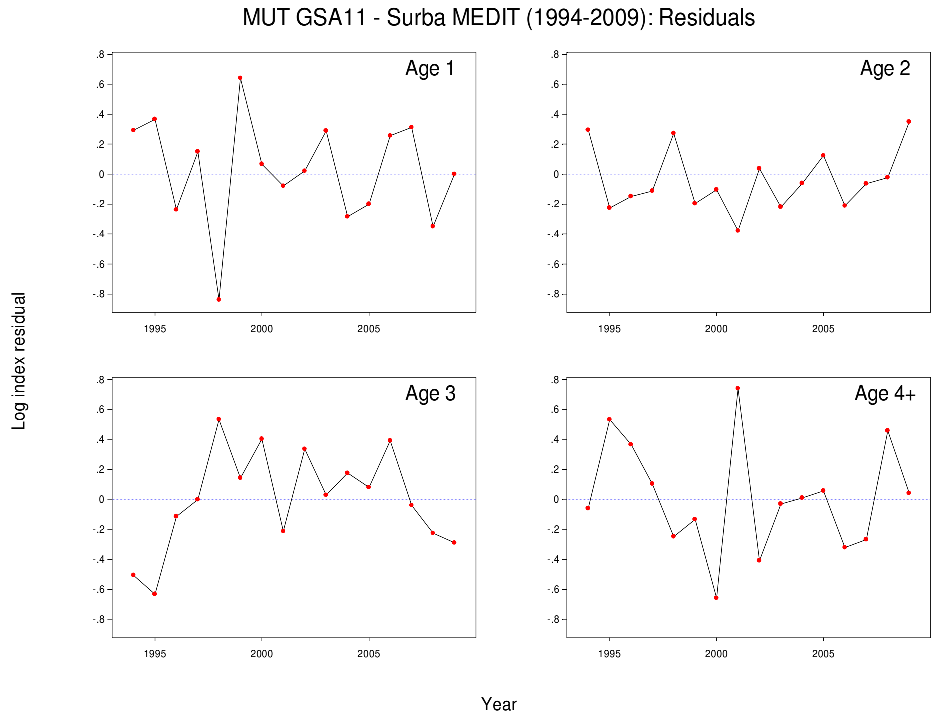
MUT GSA11 - Surba MEDIT (1994-2009): Observed (points) v. Fitted (lines)
Year class 1990
Year class 1991
Year class 1992
Year class 1993
Year class 1994
Year class 1995
Year class 1996
Year class 1997
Year class 1998
Year class 1999
Year class 2000
Year class 2001
Year class 2002
Year class 2003
Year class 2004
Year class 2005
Year class 2006
Year class 2007
Year class 2008
Log index
Age

A



MUT GSA11 - Surba MEDIT (1994-2009): log cohort abundance
Log index
2
1
0
-1
-2
-3
-4
-5
-6
-7
1992
1994
1996
1998
2000
2002
2004
2006
2008
Year

B



C

Fig. 6.5.4.1.3.3. Model diagnostic for SURBA model in the GSA 11 (MEDITS survey).
A) Comparison between observed (points) and fitted (lines) survey abundance indices, for each year. B) Log survey abundance indices by cohort. Each line represents the log index abundance of a particular cohort throughout its life. C) Log index residuals over time by age class.

6.5.4.2 Method 2: VIT LCA

6.5.4.2.1 Justification

An approach under steady state (pseudocohort) assumption was applied due to the shortness of landing by length and age (2006-2010) data. Pseudocohort, LCA and Y/R analyses as been carried out with VIT software for trawl fishery only. No discard data were included and a plus group has been used.

6.5.4.2.2 Input parameters

According to the Prodbiom approach by Caddy and Abella (1999), a vectorial natural mortality at age was computed for the stock analysis (Table 6.5.4.2.2.1). Terminal F was fixed to 0.6.

Table 6.5.4.2.2.1. Input parameters used of the analysis (sex combined) in GSA11.

VBGF M vector	L_∞=29.1 cm, K=0.41, t_0= -0.39 Age_0=1.3, Age_1=0.41, Age_2=0.27, Age_3=0.24, Age_4=0.21
Length at maturity (L50)	13 cm (sex combined)

Table 6.5.4.2.2.2. Catch numbers at length in 2006 -2010.

Length	2005	2006	2007	2008	2009	2010
0	0	0	0	0	0	0
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	441	0	0
8	0	33	0	3966	0	0
9	0	67	123	7051	0	0
10	257	1144	831	2938	46	106
11	681	1139	1364	1222	326	286
12	391	1533	1828	1240	628	245
13	466	1060	1600	979	841	235
14	133	1045	1455	929	727	346
15	585	959	1335	591	656	300
16	1433	693	994	438	749	530
17	1078	335	553	73	583	283
18	445	258	378	73	290	392
19	231	119	221	0	179	237
20	102	10	36	0	102	233
21	0	31	36	0	43	37
22	0	20	18	0	11	24
23	0	20	36	0	10	11
24	0	0	0	0	10	0
25	0	0	0	0	0	0
26	0	0	0	0	0	0
27	0	0	0	0	0	0

6.5.4.2.3 Results

Along the time series considered the red mullet landings were concentrated on age classes 1-2 and the estimated fishing mortality peaked for specimens of age class 1. $F_{0.1}$ was 0.48. F_{1-3} was 1.48 (Table 6.5.4.2.3.1, Figure 6.5.4.2.3.1).

Table 6.5.4.2.3.1. F_{bar} by years for *M. barbatus* in GSA 11.

age	Total F 06	Total F 07	Total F 08	Total F 09	Total F10	mean 06-10
0	0.19	0.10	0.84	0.12	0.06	0.26
1	2.20	2.01	2.91	1.66	1.13	1.98
2	1.51	1.66	0.60	2.04	2.26	1.61
3	0.60	0.60		0.60	0.60	0.60
Mean F	**1.12**	**1.09**	**1.45**	**1.10**	**1.01**	

year	2006	2007	2008	2009	2010	mean 06-10
$F_{(1-3)}$	1.44	1.42	1.76	1.43	1.33	1.48
$F_{(0.1)}$	0.45	0.46	0.58	0.45	0.47	0.48

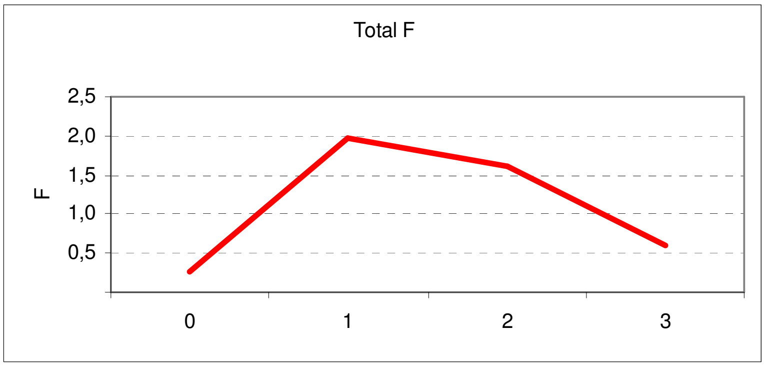


Fig. 6.5.4.2.3.1. LCA output: fishing mortality by ages of red mullet in GSA11.

Assuming no variation in the exploitation pattern, the main results of the Y/R analysis are reported in Table 6.5.4.2.3.2.

Table 6.5.4.2.3.2 The main results of the VIT analysis.

Yield (t)	Recruitment (ml)	F	Z
197008	23.1	1.19	1.80

6.5.5 Long term prediction

For the long term predictions both VIT and YIELD software were used.

6.5.5.1 Method 1: VIT

6.5.5.1.1 Justification

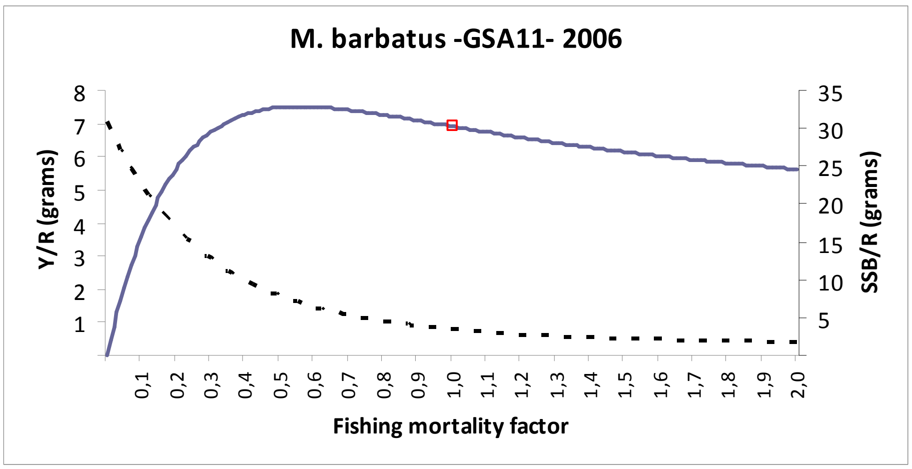
Y/R analyses as implemented in the package VIT4win (Lleonart and Salat 2000) were used to studying the stock production with increasing exploitation under equilibrium conditions.

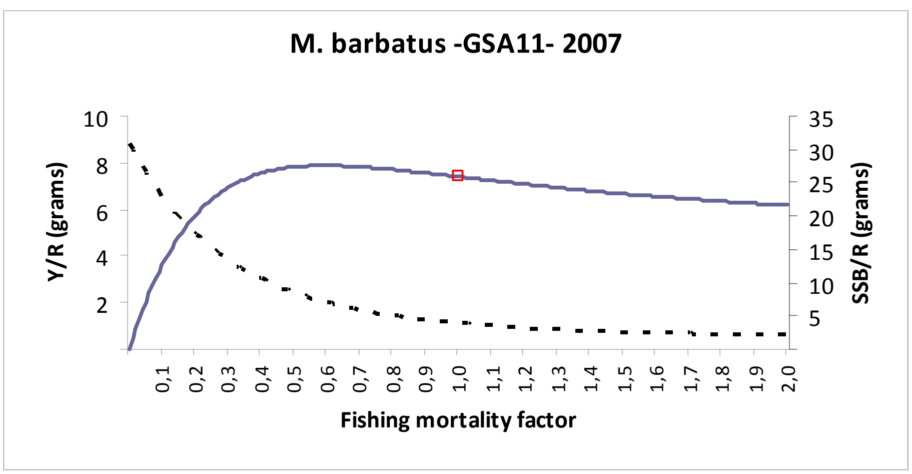
6.5.5.1.2 Input parameters

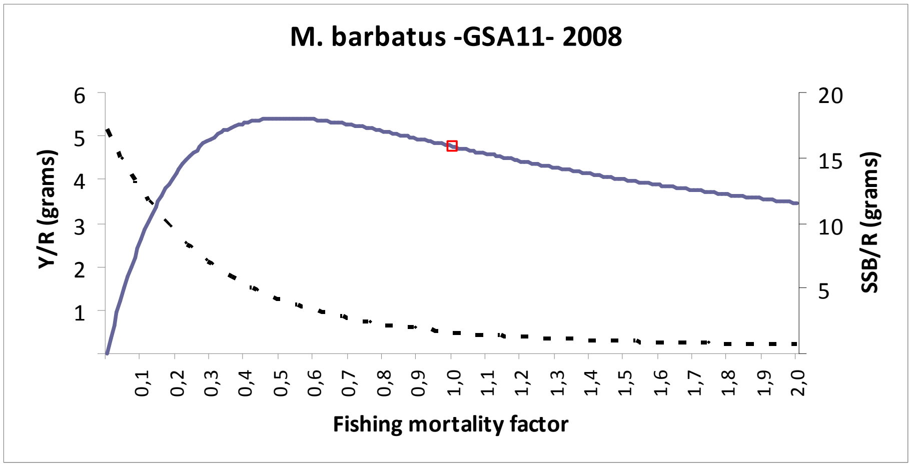
Input parameters are given in section 6.5.4.2 on the VIT assessment above. Landing data come from DCF call for GSA 11.

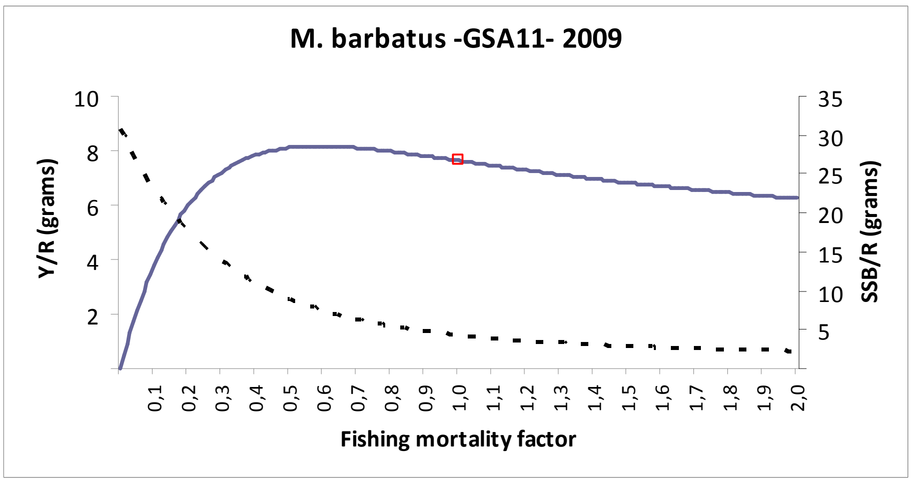
6.5.5.1.3 Results

The VIT results regarding the long term prediction are presented in the figure 6.5.5.1.3.1.









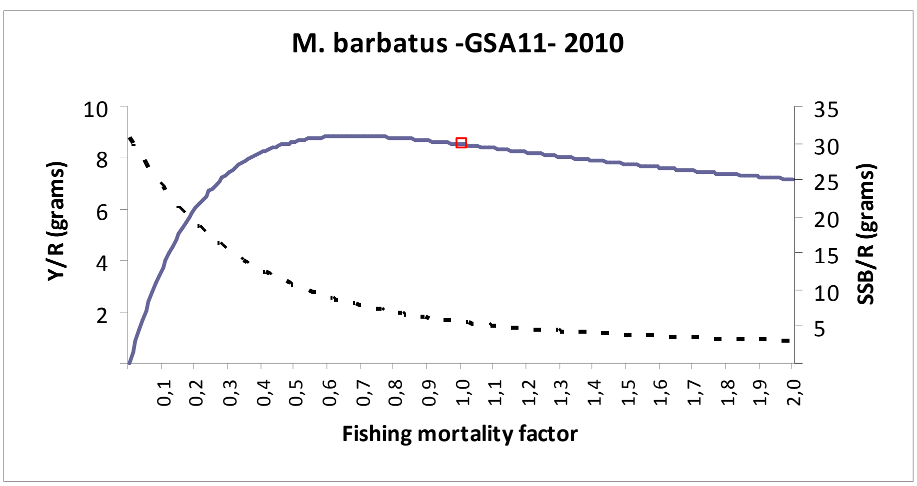


Fig. 6.5.5.1.3.1. Long term prediction from VIT results.

6.5.6 *Data quality and availability*

The landings by the artisanal fishery (GNS and GTR) seems to be underestimate because the magnitude of effort is 5 time more than the effort of OTB, while catches are less than 3% and are reported for 2008 only. Moreover, taking in to account that in all the Italian GSAs the time series of landings data for the GTR is longer, only one year of data for GTR in GSA11 seems unrealistic.

The availability and quality of survey data (MEDITS) was appropriate. Due to the fact that the survey has been generally carried out in late spring and did sample the bulk of the recruitment of the species, the assessment of the recruits from the SURBA analysis is not presented. The use of other survey results (GRUND) should help further to update the information and should be encouraged.

6.5.7 *Scientific advice*

6.5.7.1 Short term considerations

6.5.7.1.1 State of the spawning stock size

EWG 11-20 could not estimate the absolute levels of stock abundance. MEDITS survey abundance (n/km²) and biomass (kg/km²) indices which should be considered as a proxy of the spawning stock biomass, show high variability throughout the time series. Peaks of SSB are detected in 1999, 2005 and 2007. EWG 11-20 is unable to fully evaluate the status of the SSB in the absence of precautionary management reference points.

No biomass reference points have been proposed for this stock. As a result, EWG 11-20 is unable to fully evaluate the status of the stock with respect to biomass.

6.5.7.1.2 State of recruitment

No reference points have been proposed.

Relative indices estimated by SURBA indicated very high fluctuations of recruitment in the period 1994-2009, with a clear decreasing trend in the last five years.

6.5.7.1.3 State of exploitation

Both SURBA and VIT showed an overfishing status of red mullet in GSA 11. Thus, EWG 11-20 recommends that fishing effort should be reduced until fishing mortality is below or at the proposed level F_{MSY}, in order to avoid future loss in stock productivity and landings. To achieve this goal a multi-annual management plan is required.

6.6 Stock assessment of anchovy in GSA 22

6.6.1 Stock identification and biological features

6.6.1.1 Stock Identification

This assessment of the anchovy stock in GSA 22 has been based on information derived from the Greek part of the Aegean Sea (GSA 22). The main distribution area of the anchovy stock in Aegean Sea is located in the continental shelf of the northern Aegean Sea (Giannoulaki *et al*., 2004; 2008a; Somarakis *et al*., 2007). Anchovy juveniles spatial distribution is strongly related to semi closed gulfs, shallow waters (less than 50 m depth) with high productivity, often related to areas of rivers outflows (Tsagarakis *et al*., 2007; 2008; SARDONE project interim report).

6.6.1.2 Growth

Fast growth parameter was considered and parameters are shown in table 6.6.1.2.1. No sex discrimination was applied. Natural mortality M was estimated based on ProBiom (Abella *et al.*, 1997) as recommended in the report of the SG-ECA/RST/MED 09-01.

Table 6.6.1.2.1. Growth parameters (v. Bertalanffy) for anchovy in GSA 22.

	Fast growth Unsexed	Units
Linf	191	cm
K	0.385	$year^{-1}$
t0	-1.559	year
a	0.00004	gr
b	3.1157	
M age 0	1.5	year⁻
M age 1	1	year⁻
M age 2	0.72	year⁻
M age 3	0.66	year⁻
M age 4	0.62	year⁻

6.6.1.3 Maturity

The following maturity at age ogive was used for assessments in GSA 22 estimated from biological sampling and the DEPM surveys (Somarakis *et al.*, 2004; 2007). Length at first maturity is estimated approximately at 105 mm (Somarakis, 1999; Somarakis *et al.*, 2004; 2007) in Aegean Sea. The anchovy spawning period in GSA 22 extends from May to August with a peak in June-July. The major spawning grounds of anchovy in the Aegean Sea are located in areas characterized by wide continental shelf and enrichment processes associated with the outflow from large rivers or the Black Sea Water (BSW) in the northern Aegean Sea. Consequently, the highest egg densities have been typically observed over the northern Aegean Sea continental shelf.

Table 6.6.1.3.1. Maturity ogives at age for female anchovy in GSA 22.

Year	Age 0	Age 1	Age 2	Age 3	Age 4
2003	0	0.62	0.99	1	1
2004	0	0.67	0.99	1	1
2005	0	0.46	0.98	1	1
2006	0	0.40	0.98	1	1
2007	0	0.40	0.98	1	1
2008	0	0.40	0.98	1	1

6.6.2 Fisheries

6.6.2.1 General description of fisheries

Anchovy (*Engraulis encrasicolus*) is one of the most important target species for the purse seine fishery in GSA 22. Anchovy is being exploited only by the purse seine fishery. Pelagic trawls are banned and benthic trawls are allowed to fish small pelagics in percentages less than 5% of their total catch. Commonly anchovy is caught from shallow waters about 30 m to 100 m depth.

6.6.2.2 Management regulations applicable in 2008 and 2009

Regarding the management regulations enforced they concern a closed period from the mid December till the end of February and technical measures such as minimum distance from shore (300 m), minimum bottom depth (30 m), gear and mesh size, engine, GRT restrictions etc. There is also a minimum landing size at 9 cm.

6.6.2.3 Catches

6.6.2.3.1 Landings

The trend in reported landings (from Greek purse seiners fleet) is shown in figures 6.6.2.3.1.1 and 6.6.2.3.1.2. Landings were obtained within the framework of the Hellenic Centre for Marine Research data collection system that covers the entire GSA 22. The data from 2003 to 2008 were reported to STECF-EWG 11-20 through the Data Collection Regulation and are listed in Table A3.4 of Appendix 3. An increasing trend in anchovy landings has been observed (Figure 6.6.2.3.1.1). Data of the landings per vessel class indicate that small vessels (12-24 m) (Figure 6.6.2.3.1.2) are mainly responsible for anchovy catches (>70% of anchovy catches).

Annual lengths of landings were reported to STECF EWG 11-20 for 2003-2008 and are shown in figure 6.6.2.3.1.3. No data on the age distribution of landings was reported to the STECF EWG 11-20, through the

DCR. Figure 6.6.2.3.1.4 shows the landings at age in GSA 22 as reported to EWG 11-20 for 2003-2006. Data for 2007 and 2008 are based on data obtained within the framework of the Hellenic Centre for Marine Research data collection system that covers the entire GSA 22. No data were reported or become available by HCMR for 2009, 2010 and 2011.

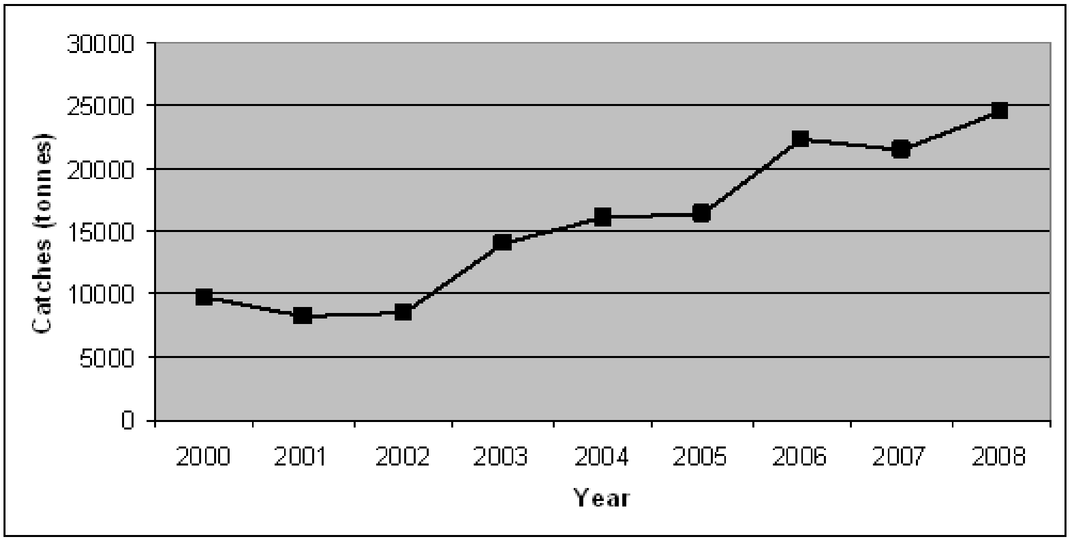


Fig. 6.6.2.3.1.1. Anchovy landings (tons) in GSA 22 for 2000-2008.

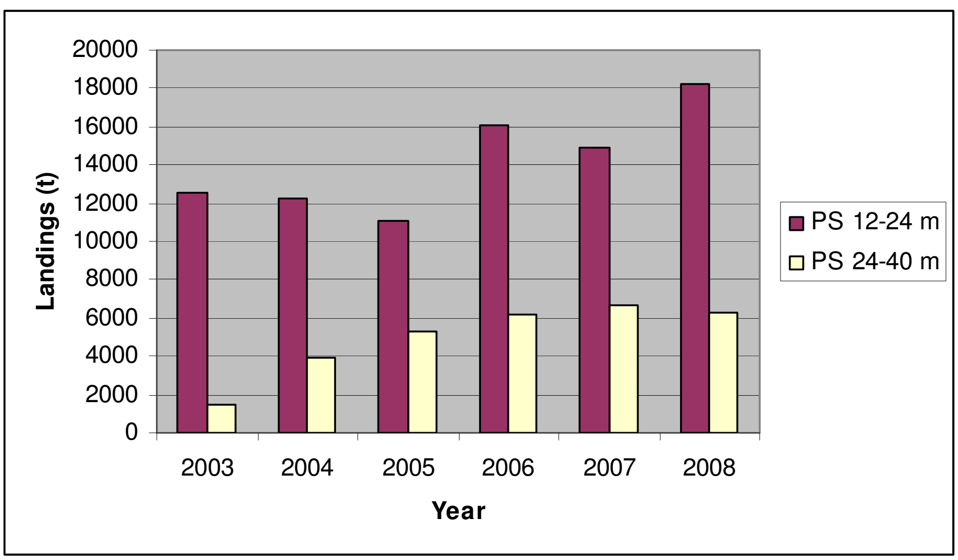


Fig. 6.6.2.3.1.2. Anchovy landings (tons) in GSA 22 per fleet size.

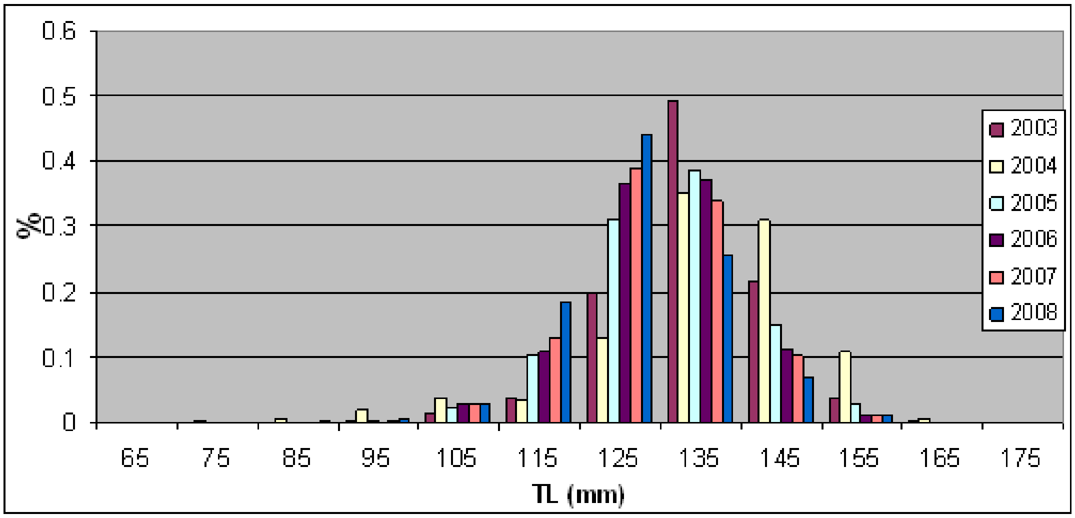


Fig. 6.6.2.3.1.3. Length frequency distribution of anchovy landings (tons) in GSA 22 for 2003-2008.

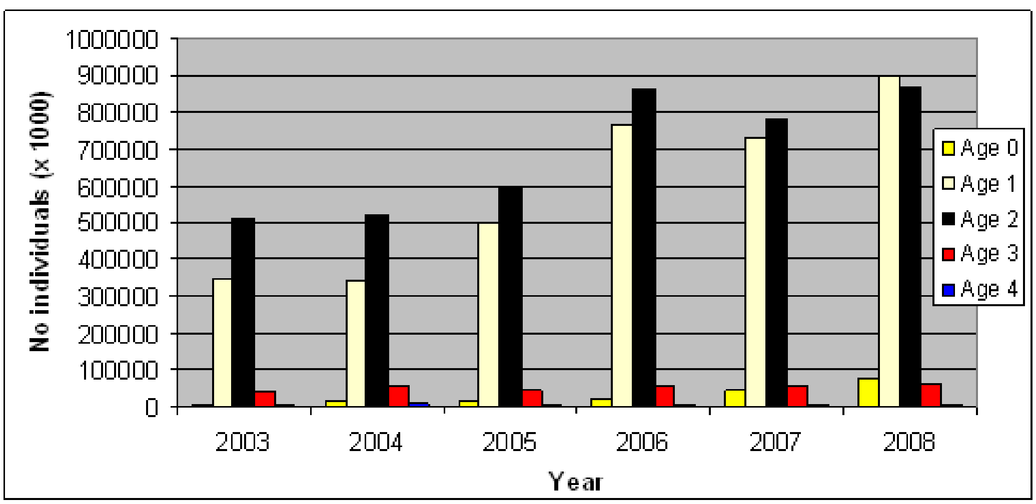


Fig. 6.6.2.3.1.4. Anchovy landings per age group (number of individuals in thousands) in GSA 22 for 2003-2008.

6.6.2.3.2 Discards

No discards data for anchovy were reported to the STECF EWG 11-20 and no data were reported through the Data collection regulation for 2003-2008. According to data obtained within the framework of the Hellenic Centre for Marine Research data collection system that covers the entire GSA 22, discards are estimated to less than 1%, consisting 0.06% of the purse seine fishery total catch. Although considered negligible they were taken into account for the assessment as a percentage to reported landings. The fishery is multispecies and fishermen tend to avoid schools of undersized anchovies due to sorting difficulties (blocking of the mesh) and low price, practically by using nets of bigger mesh size, targeting mostly mackerels or horse mackerels.

6.6.2.4 Fishing effort

Based on the fishing effort data reported through the Data collection regulation and data obtained within the framework of the Hellenic Centre for Marine Research data collection system covering the entire GSA 22, the following table was made:

Table 6.6.2.4.1 Effort data for the purse seine fleet in GSA 22 (GT=Gross tonnage, KW=engine power).

Year	PS 12-24 m	PS 24-40 m	PS 12-24 m	PS 24-40 m	PS 12-24 m	PS 24-40 m
	Days at Sea	**Days at Sea**	**Days at Sea x GT**	**Days at Sea x GT**	**Days at Sea x KW**	**Days at Sea x KW**
2003	41539	2942	1767398	230726	8709727	679624
2004	39783	3989	1620847	366709	8111571	1029410
2005	42520	5690	1753346	542120	8123673	1532790
2006	37255	5619	1568893	539146	7386042	1606608
2007	31492	5338	1305252	524544	6511187	1528440
2008	35090	4938	1457212	473121	6898061	1335582

6.6.3 Scientific surveys

6.6.3.1 Acoustics and DEPM

6.6.3.1.1 Methods

6.6.3.1.1.1 Acoustics

Based on data reported to STECF EWG 11-20 total biomass, abundance, length and age composition for GSA 22 were estimated by acoustics from 2003 to 2008. No age distribution data were reported through the DCR for 2008, 2009, 2010, 2011. No acoustic survey took place in 2007, 2009, 2010 and 2011.

6.6.3.1.1.2 Acoustic surveys methodology

Acoustic echoes were registered continuously along 70 pre-defined transects in the study area in June 2003, 2004, 2005, 2006 and 2008 with a Biosonics Split Beam 38 kHz DT-X echosounder. The acoustic methodology followed is described in Somarakis *et al.* (2007) (GFCM 2007 related WD). Hydroacoustic data analysis was performed using the Sonardata Echoview software v3.30. Echo trace classification was applied based on:

a) echogram visual scrutinisation and direct allocation of school marks that characterise anchovy as well as

b) allocation on account of representative fishing stations that were held along transects (MacLennan and Simmonds, 1992).

In order to estimate anchovy biomass, the length-weight relationship is required as well as species length frequency distribution per area. Therefore, 22, 23, 27, 37 and 30 pelagic trawls were made along transects in 2003, 2004, 2005, 2006 and 2008 respectively, in the positions of high fish concentrations. A random sample of 200 specimens was obtained from each haul for further laboratory analysis. Subsequently, the length-weight relationship was estimated from the total number of hauls according to the equation:

$$W = a\,L^b$$

where W is the total weight; L is the total length and a and b are constants that are estimated by regression analysis.

The mean length frequency was estimated in two sub-areas: (a) Eastern area (Thracian Sea and Strymonikos Gulf) and (b) Western area (Thermaikos and Evoikos Gulfs). In the two sub-areas, the mean frequency of each length class was estimated as follows:

$$f_j = \frac{\sum_{k=1}^{M} \left(\frac{n_{jk}}{t_k} \right)}{\sum_{k=1}^{M} \left(\frac{N_k}{t_k} \right)}$$

where f_j is the mean frequency of anchovy of length class j; n_{jk} is the number of specimens of length class j in haul k; N_k is the total number of anchovies in haul k; t_k is the duration of haul k and M is the number of hauls in the area. The above equation is appropriate even if the catches are small and the length distributions are poorly defined. It takes accounts of the haul duration, since it is supposed that on average, longer hauls will produce more fish (MacLennan and Simmonds, 1992).

The density of targets (F) from the observed echo integrals were estimated according to the equation F= (K/<σ>)E, were K is the calibration factor, <σ> is the mean cross-section and E is the echo integral after partitioning (MacLennan and Simmonds, 1992). The target strength (TS) – total length relationship used for anchovy was: TS=20 logL-71.2, where L is fish total length (ICES, 2006). The <σ> was calculated for the mean total fish length of each area according to the equations $<\sigma>= 4\pi \sum_{\iota} f_i 10^{TS/10}$, where f_I is the corresponding length frequency as deduced from the fishing samples (MacLennan and Simmonds, 1992).

The abundance Q was estimated separately for the eastern and the western part of the study area. The abundance Q in each elementary statistical sampling area was calculated from the average density within each sub-area according to the equation:

$$Q = A_k \sum_i F_i / N_k ,$$

where F_i is the i sample; A_k is the area of each elementary statistical sampling area and N_k is the number of transects in A_k. The variance V was estimated as

$$V = \sum_i \ (AF_I - Q)^2 / [N_r(N_{r-1} - 1)]$$

The data were log transformed and the means and variances of F estimated according to the following equations:

$F = \exp(m) \mathbf{G_N}[0.5\ S/(n-1)$; $V = F^2 - \exp(2m)\ \mathbf{G_N}[S(n-2)/(n-1)^2]$;

where m = average (lnF); S= variance (lnF) and n = independent observations of F.

The total abundance Q_t and its variance were obtained by summing the results for each region $Q_t = Q_1 + Q_2 + \ldots$, and $V_t = V_1 + V_2 + \ldots$. Standard error of Q_t is the square root of V (MacLennan and Simmonds, 1992).

6.6.3.1.1.3 Daily Egg Production surveys (DEPM) methodology

The methodology of the DEPM is described in detail in Somarakis *et al*. (2007) GFCM WD. The spawning stock biomass was estimated according to the model described by Parker (1980) and subsequently modified by Stauffer & Picquelle (1980):

$$B = (k \cdot P \cdot A \cdot W)/(R \cdot F \cdot S)$$

where, *B* = spawning stock biomass in metric tons, k = conversion factor from grams to metric tons, *P* = daily egg production (number of eggs per sampling unit, m^2), A = total survey area (in sampling units, m^2), *W* = average weight of mature females (grams), *R* = sex ratio (fraction of mature females by weight), *F* = batch fecundity (mean number of eggs per mature females per spawning), *S* = fraction of mature females spawning per day (spawning frequency).

6.6.3.1.2 Geographical distribution patterns

No analyses were conducted during EWG 11-20.

6.6.3.1.3 Trends in abundance and biomass

Fishery independent information regarding the state of the anchovy stock in GSA 22 was derived from the acoustics and the DEPM surveys. Figure 6.6.3.1.3.1 displays the estimated trend in anchovy Total Biomass (estimated by acoustics) and Spawning Stock Biomass (estimated by DEPM) for GSA 22. Figure 6.6.3.1.3.2 shows the estimated trend in anchovy abundance (estimated by acoustics).

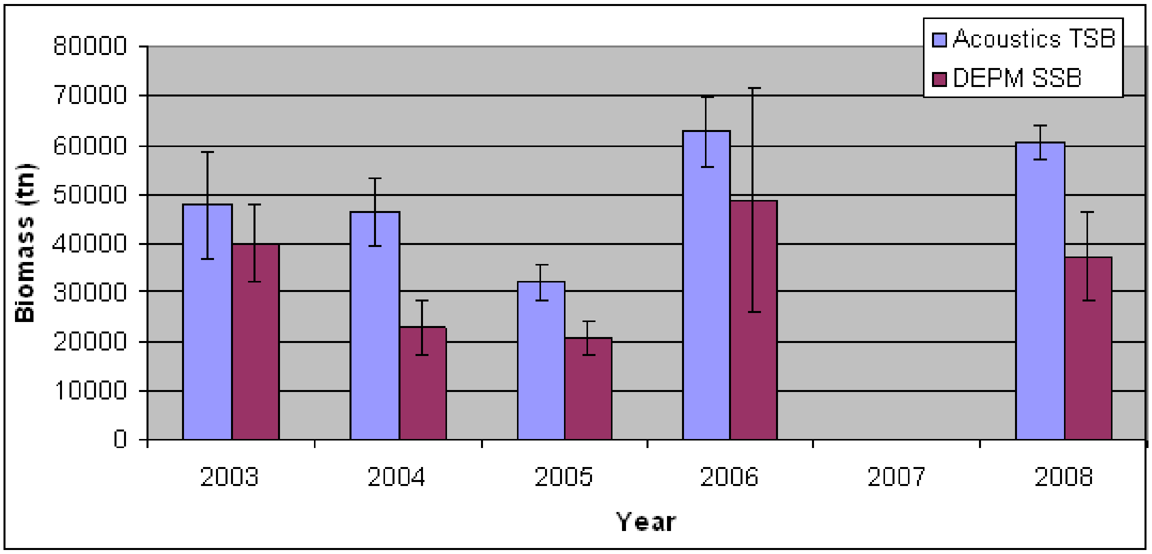


Fig. 6.6.3.1.3.1. Estimated anchovy biomass indices for GSA 22, 2003-2006 and 2008.

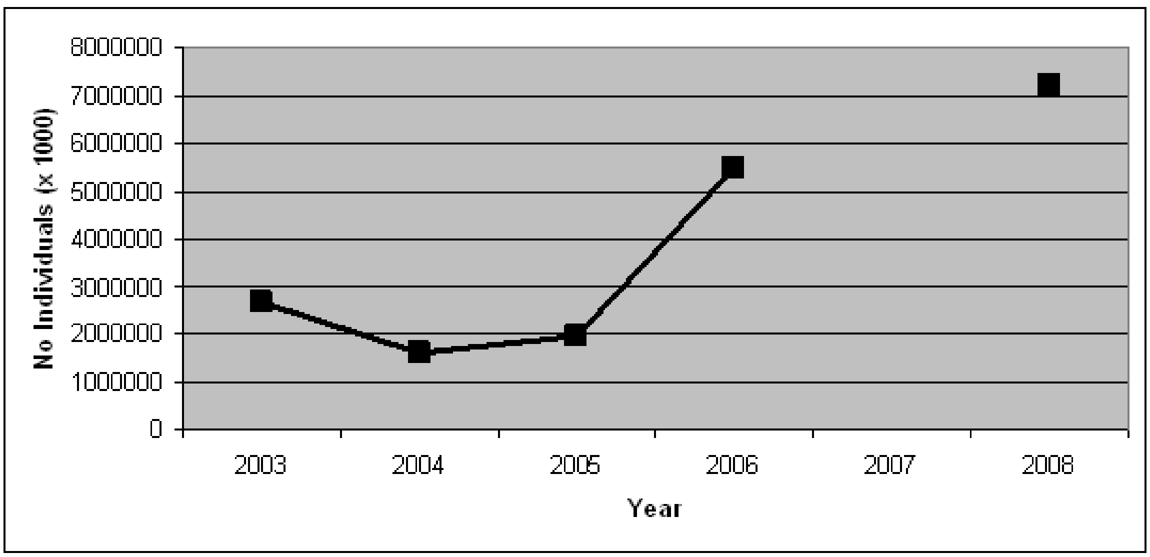


Fig. 6.3.3.1.3.2. Estimated abundance indices for GSA 22, 2003-2006 and 2008.

An increasing trend was observed in both biomass and abundance indices (Fig. 6.6.3.1.3.1, Fig. 6.6.3.1.3.2).

6.6.3.1.4 Trends in abundance by length or age

Figure 6.6.3.1.4.1 shows the length frequency composition of the anchovy stock as derived from the acoustic surveys in GSA 22.

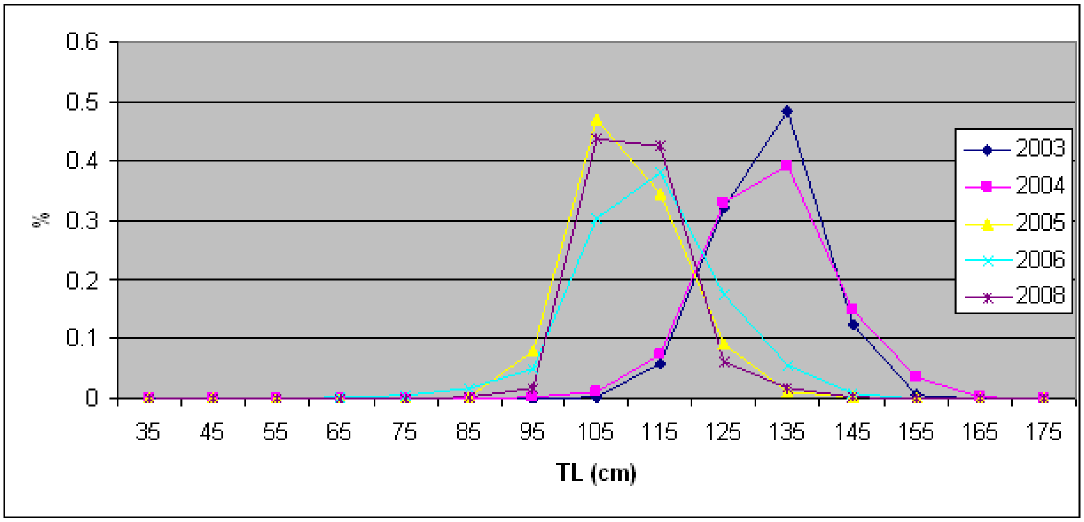


Fig. 6.6.3.1.4.1. Estimated changes in size compositions for GSA 22 for 2003-2006 and 2008.

The following figure 6.6.3.1.4.2 and figure 6.6.3.1.4.3 show the abundance indices by size and age of GSA 22 for 2003-2006 and 2008 based on acoustic surveys.

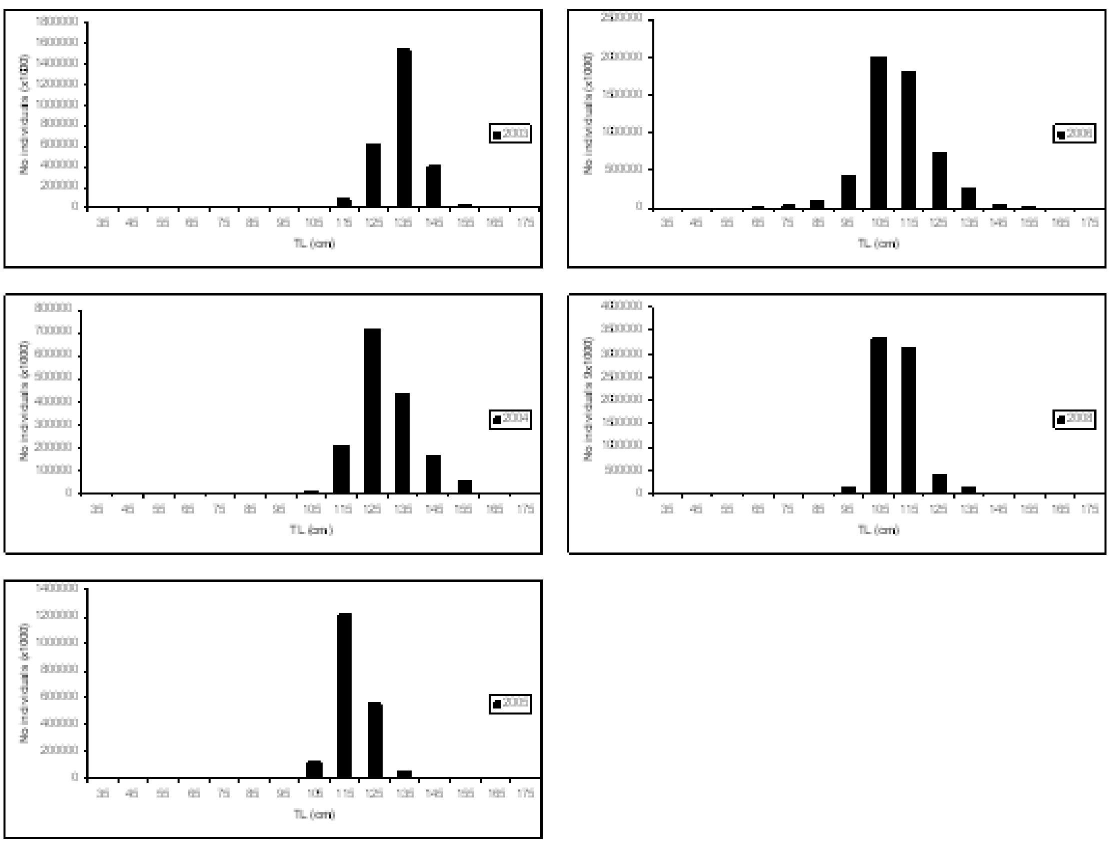


Fig. 6.6.3.1.4.2. Abundance indices by size for 2003-2006 and 2008.

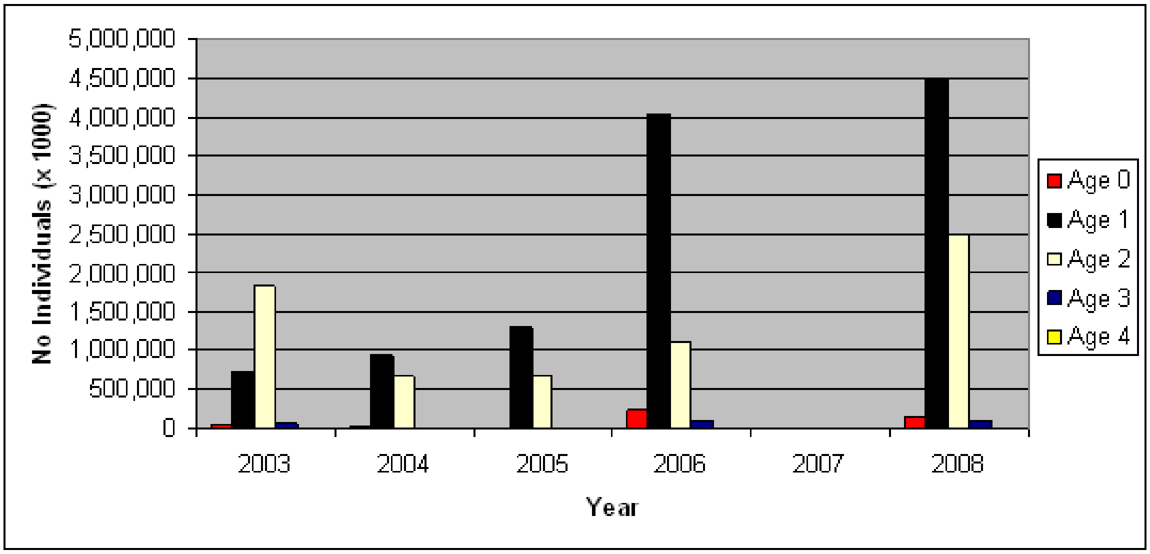


Fig. 6.6.3.1.4.3. Abundance indices by age for 2003-2006 and 2008.

6.6.3.1.5 Trends in growth

No analyses were conducted during STECF EWG 11-20. Growth equation was supplied through DCR and it was estimated based on aggregated data collected in GSA 22 for the period 2003 to 2008.

6.6.3.1.6 Trends in maturity

No analyses were conducted during STECF EWG 11-20. Maturity ogive based on the results of the DEPM surveys was used (Table 6.6.3.1.6.1).

Table 6.6.3.1.6.1. Maturity ogive for anchovy in GSA 22 based on the results of DEPM surveys.

Age	2003	2004	2005	2006	2008
0	0	0	0	0	0
1	0.62	0.67	0.46	0.4	0.4
2	0.99	0.99	0.98	0.98	0.98
3	1	1	1	1	1
4	1	1	1	1	1

6.6.4 Assessment of historic stock parameters

Anchovy stock in GSA 22 has been previously assessed for the given historic time series by means of Integrated Catch at Age analysis in the framework of SGMED 09-02. Since there was no update on data available for the specific stock, the suggestion of the STECF EWG 11-20 was to assess the stock by a different analytical methodology and compare results with the assessment done in SGMED 09-02.

6.6.4.1 Method: XSA.

6.6.4.1.1 Justification

This assessment is based on fishery independent surveys information as well as on **Extended Survivors Analysis** (XSA) analysis model. Extended Survivors Analysis for stock assessment (Shepherd, 1999) was applied. XSA uses virtual population analysis (VPA) (Pope & Shepherd, 1985) with weighted tuning indices. Specifically, acoustic surveys estimations were used for an age structured abundance index. XSA assessment method is a tuned VPA method that focuses on the relationship between the tuning index and population abundance, allowing the use of a more complicated model for the relationship between tuning index and year class strength at the youngest ages.

This assessment of the anchovy stock in GSA22 is based on a short time series of available, so results should be considered with caution. In addition Y/R analysis was applied during the STECF EWG 11-20.

6.6.4.1.2 Input parameters

XSA was based on commercial catch data (2000-2008). Abundance at age estimates from acoustic surveys over the period 2003-2006 and 2008 were used as tuning index. Anchovy data concerned annual anchovy landings, annual anchovy catch at age data (2000-2008), mean weights at age, maturity at age and the results of acoustic and DEPM surveys (2003-2006 and 2008) presented in Tables 6.6.4.1.2.1 to 6.6.4.1.2.6. Age-Length-Key was applied on a six month basis to convert length distribution into age distribution. In addition discards were taken into account. Specifically, according to data obtained within the framework of the Hellenic Centre for Marine Research data collection system that covers the entire GSA 22, discards are estimated to less than 1%, consisting 0.06% of the purse seine fishery total catch. Although considered negligible they were taken into account for the assessment as a percentage to reported landings.

Acoustic estimates were used as an index for the numbers at age of the population. The reference age for the fishery was age group 2, as fully exploited and fully recruited. The default values of the FLXSA control were used to run the analysis taking into account that the survey is held in the middle of the year. Different natural mortality values were applied per age group but constant for all years based on ProBiom (Abella *et al.*, 1997) as recommended in the report of the SG-ECA/RST/MED 09-01. This method for estimating natural mortality is consistent with the methodology used in GSAs 5, 6 and 17 for small pelagics. Average values of maturity ogive and weight at age in the stock were used for 2007.

Table 6.6.4.1.2.1. Catch at age (numbers in thousands) of anchovy stock in GSA 22 for 2000-2008.

Year	0	1	2	3	4
2000	8859	287419	357849	27449	2160
2001	14506	286470	297203	19457	1000
2002	9803	304095	328428	23198	1269
2003	4676	348900	513289	41899	3881
2004	16315	342761	521446	57843	8527
2005	14523	498088	591543	43454	3003
2006	21930	766824	863957	57795	6472
2007	46515	731249	782267	58787	5727
2008	75828	892863	866883	64421	2531

Table 6.6.4.1.2.2. Catch estimates (in tons) of anchovy stock in GSA 22 for 2000-2008.

Year	Anchovy
2000	10348
2001	8726
2002	9063
2003	14843
2004	17064
2005	17327
2006	24461
2007	22791
2008	25950

Table 6.6.4.1.2.3. Weight at age in the catch of anchovy stock (in kg) in GSA 22 for 2000-2008.

	Year								
Age	2000	2001	2002	2003	2004	2005	2006	2007	2008
0	0.0085	0.0093	0.0098	0.0057	0.0029	0.0036	0.0099	0.0102	0.0105
1	0.0125	0.0134	0.0133	0.0164	0.0146	0.0096	0.0151	0.0139	0.0127
2	0.0138	0.0151	0.015	0.0184	0.0184	0.0137	0.0161	0.0153	0.0146
3	0.0145	0.0161	0.0161	0.0188	0.0204	0.016	0.0174	0.0176	0.0179
4	0.0245	0.0297	0.0257	0.0398	0.0338	0.0334	0.0187	0.0223	0.0258

Table 6.6.4.1.2.4. Weight at age in the stock (in kg) of anchovy stock in GSA 22 for 2000-2008.

	Year								
Age	2000	2001	2002	2003	2004	2005	2006	2007	2008
0	0.005	0.005	0.005	0.0057	0.0033	0.0014	0.0017	0.0016	0.0015
1	0.0011	0.0011	0.0011	0.0058	0.0086	0.0056	0.0067	0.0083	0.0098
2	0.0136	0.0136	0.0136	0.0201	0.0201	0.0147	0.0191	0.0167	0.0143
3	0.0153	0.0153	0.0153	0.0293	0.0224	0.0246	0.0231	0.0219	0.0207
4	0.0179	0.0179	0.0179	0.0398	0.0338	0.0334	0.0209	0.0227	0.0245

Table 6.6.4.1.2.5. Maturity ogive of anchovy stock in GSA 22 for 2003-2008.

Year	0	1	2	3	4
2003	0	.62	.99	1	1
2004	0	.67	.99	1	1
2005	0	.46	.98	1	1
2006	0	.40	.98	1	1
2007	0	.40	.98	1	1
2008	0	.40	.98	1	1

Table 6.6.4.1.2.6. Age-structure indices of anchovy (numbers in thousands) stock in GSA 22 for 2003-2008. Age 3 was considered a plus age group.

Age	2003	2004	2005	2006	2007	2008
1	711816	925773	1291270	4044093	-1	4469332
2	1822817	667953	663465	1109500	-1	2495923
3+	69679	5177	7524	99442	-1	95920

6.6.4.1.3 Results including sensitivity analyses

The residual plot of the catchability per age and year of the model are shown in figure 6.6.4.1.3.1 generally showed good model fit besides the survey index at age 3 in 2004 and 2006. This could be attributed either to the low representation of ages 3 and 4 in the catch and the population or due to misinterpretation of the age readings estimations.

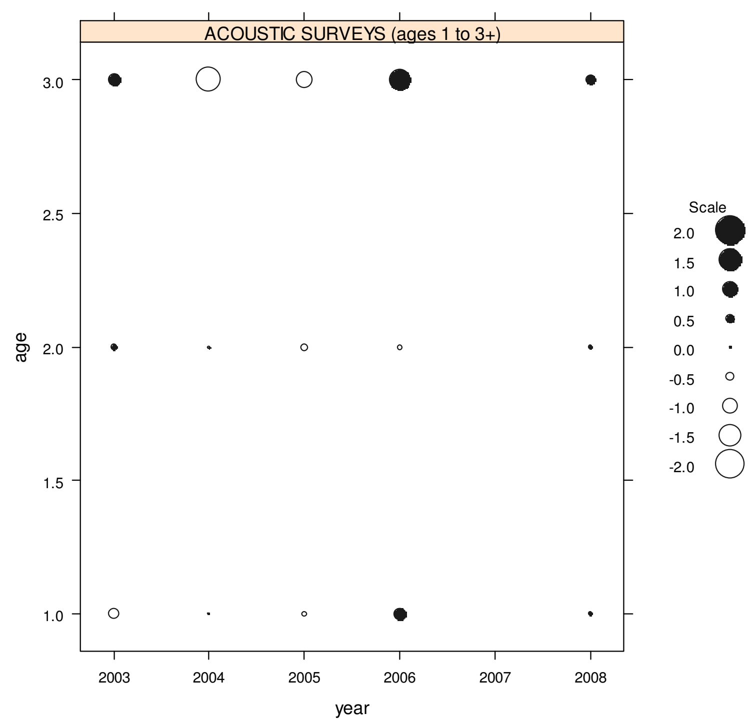


Fig. 6.6.4.1.3.1. Residual plot of index catchabilities per age and year of anchovy XSA model for GSA 22 (2003-2008)

The model diagnostics are also shown in the table 6.6.4.1.3.1.

Table 6.6.4.1.3.1. Anchovy XSA model diagnostics. a. Tuning index residuals b. Index hat values and c. Index variance.

a. Index residuals

	2003	2004	2005	2006	2007	2008
1	-0.630	0.035	-0.217	0.690	NA	0.121
2	0.327	0.108	-0.340	-0.230	NA	0.135
3	0.692	-1.502	-0.982	1.292	NA	0.501

b. Index Hat values

	2003	2004	2005	2006	2007	2008
1	4142481	9090158	9688112	26119473	NA	21831551
2	30029894	21325961	15770499	23898615	NA	37682518
3	542865	71463	81422	956763	NA	636693

c. Index variance

	2003	2004	2005	2006	2007	2008
1	1.393	1.393	1.393	1.393	NA	1.393
2	29.0912	29.0912	29.0912	29.0912	NA	29.0912
3	3.4381	3.4381	3.4381	3.4381	NA	3.4381

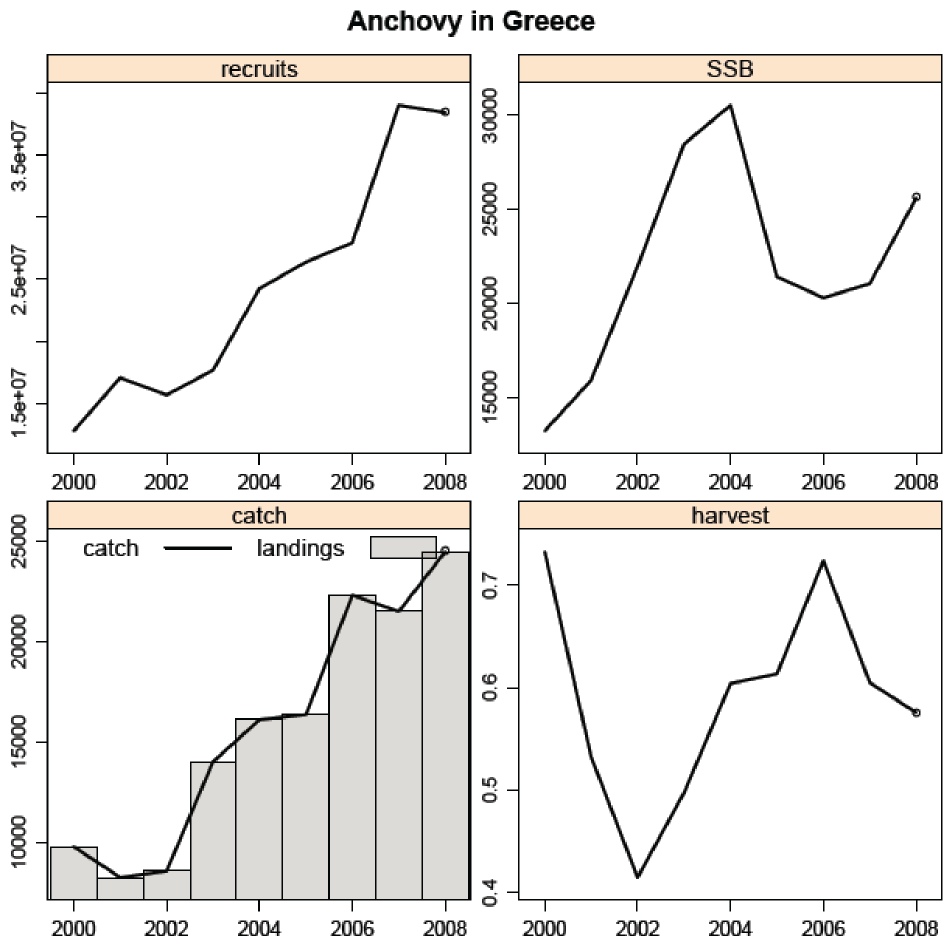
d. log catchabilities

	2003	2004	2005	2006	2007	2008
1	-0.63	0.035	-0.217	0.69	NA	0.121
2	0.327	0.108	-0.34	-0.23	NA	0.135
3	0.692	-1.502	-0.982	1.292	NA	0.501

e. Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

	1	2	3
Mean_Logq	-0.2227	1.0582	-1.0315
S.E_Logq	0.4839	0.2761	1.1851

XSA model results for anchovy stock in GSA 22 are shown in figure 6.6.4.1.3.2, indicating an increasing trend for recruitment since 2004, stabilizing since 2007. A decrease in SSB was observed since 2004 but with a slight increase since 2007 to 2008. Average fishing mortality for ages 1 to 3 (which are target ages for the fishery) shows an increase since 2002 but decreasing since 2006.



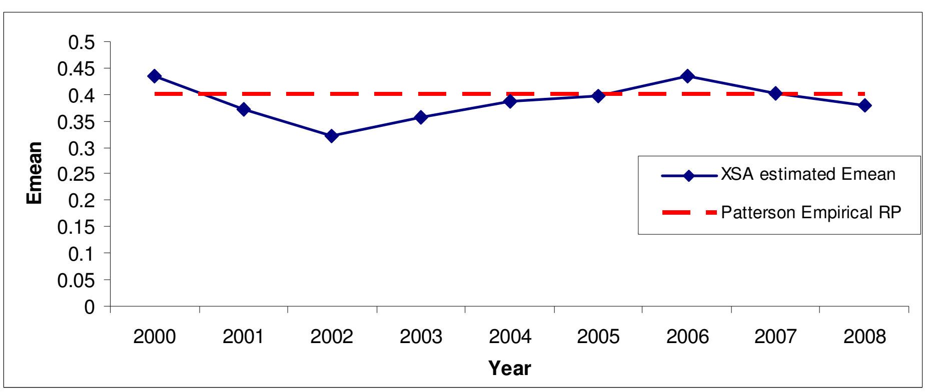
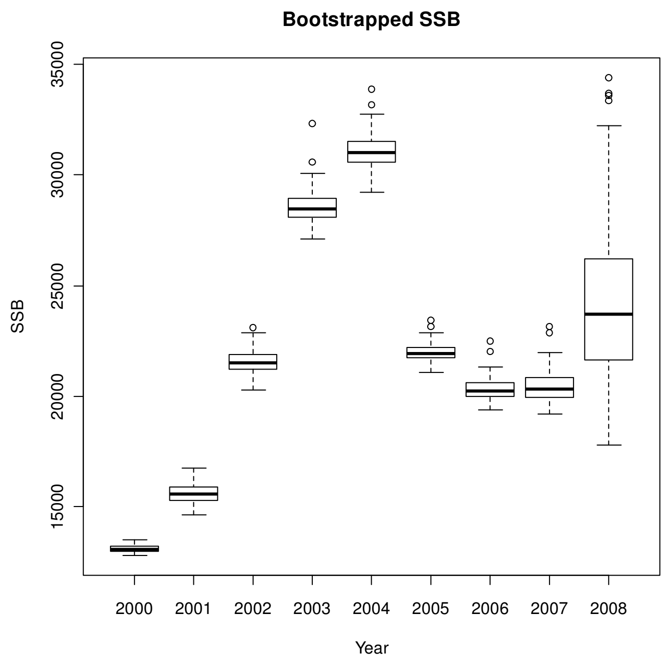
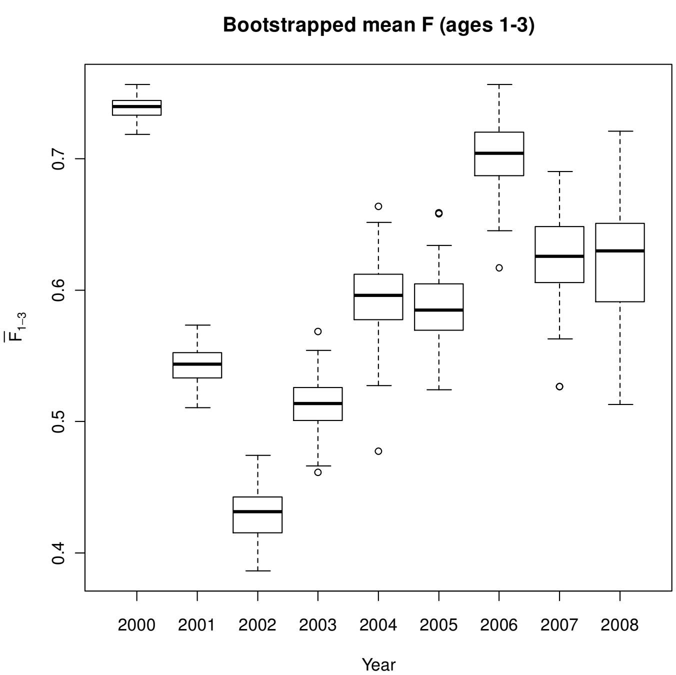


Fig. 6.6.4.1.3.2. Anchovy XSA Model results: Recruitment, SSB, Total biomass, exploitation rate (F/Z), F mean for ages 1-3, landings to biomass ratio.

The estimated exploitation ratio seems to fluctuate around the 0.4 value, being below 0.4 at 2008.

Bootstrapping of the XSA model was also applied with 100 iterations in order to have an estimation of the uncertainty in the SSB, recruitment and Fbar estimates. Results are presented in figure 6.6.4.1.3.3.


Bootstrapped SSB
SSB
15000
20000
25000
30000
35000
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year


Bootstrapped mean F (ages 1-3)
$\bar{F}_{1-3}$
0.4
0.5
0.6
0.7
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year

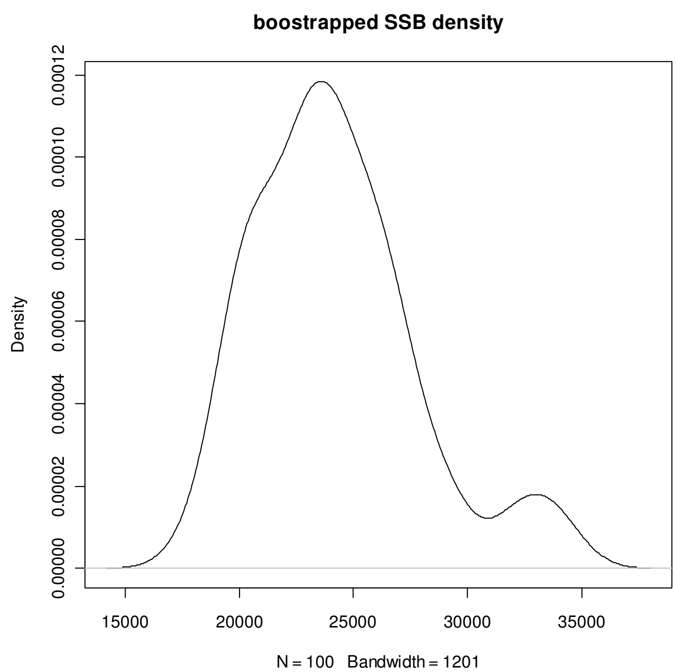
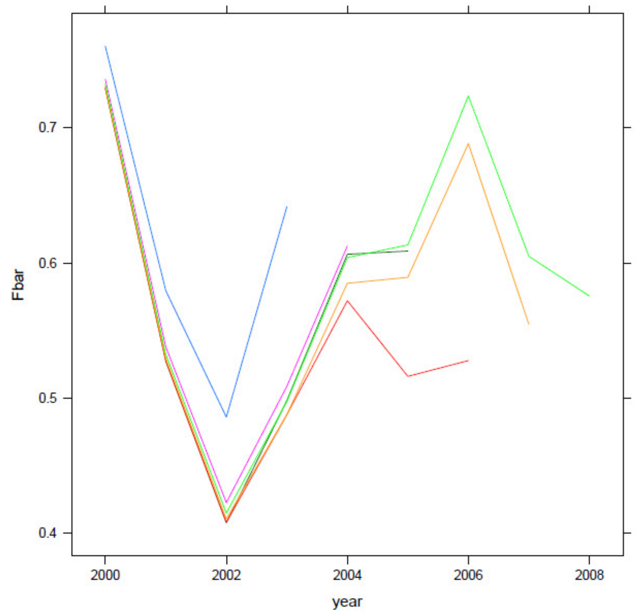
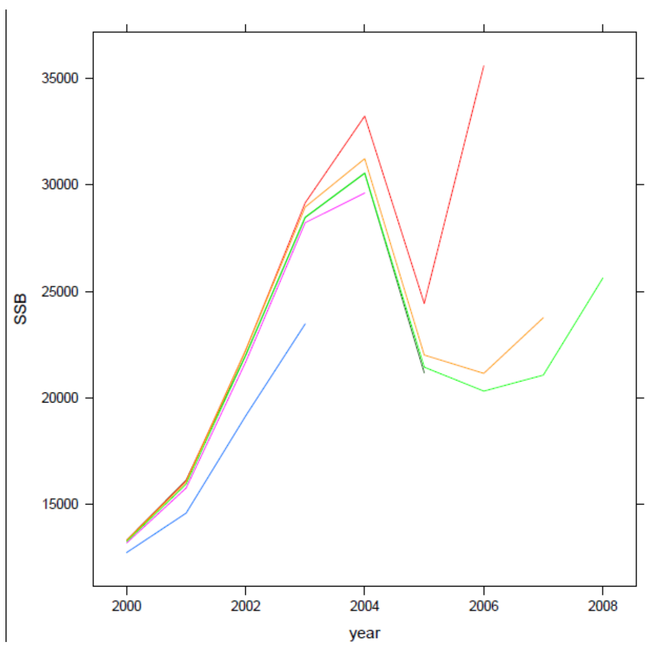


Fig. 6.6.4.1.3.3. Anchovy XSA Model (M variable per age group based on ProBiom estimations, acoustic surveys index) results: Bootstrapped Recruitment, Bootstrapped SSB and bootstrapped Fmean and bootstrapped ssb ddensity for ages 1-3.

Retrospective analysis was applied in the XSA model for the Aegean Sea anchovy 2000-2008 with up to 5 years backward analysis. Results are presented in figure 6.6.4.1.3.4, showing no particular retrospective bias and consistency except for the recruitment in 2004-2006 and SSB in 2006.





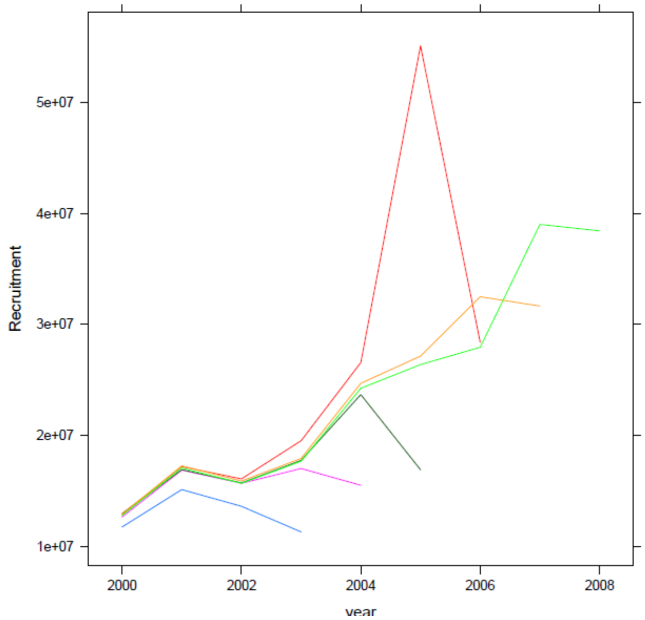


Fig. 6.6.4.1.3.4. The results of retrospective analysis in the Ionian Sea anchovy XSA model 2000-2008, concerning F mean 1-3, SSB and recruitment.

Comparison of XSA outcome with the ICA stock assessment outcome as it was held in the framework of SGMED 09-02 generally showed similar results. Any observed deviations in the trends are explainable due to differences in the tuning methodology followed by the two approaches. ICA stock assessment by SGMED 09-02, tuning was performed both by an age structure index based on acoustics as well as a biomass index based on Daily Egg Production estimates. XSA methodology allows only the use of age structure indices thus biomass index was not used. Specifically, concerning SSB a similar increasing trend was observed since 2006. In the terminal year 2008 it was estimated around 60000 tons based on ICA estimates and around 27000 tons based on XSA estimates. Taking into consideration DEPM results the XSA SSB estimates might be considered as slight underestimates. Concerning recruitment ICA estimated an extremely high value for the terminal year 2008, whereas XSA seems to estimate a more realistic estimate. The increasing trend in recruitment is observed in the results of both approaches. Higher variability in the exploitation pattern estimated by XSA compared to the one by ICA which seems to stabilize since 2005 around 0.4. XSA results showed a minimum F value in 2002 followed by an increasing trend up to 2006 and then falling around 0.55 in 2008. Thus the exploitation rate is more variable in the case of XSA, however remains on average around 0.38 for the time series, being below E=0.4. The similar results by both approaches despite the deviation in tuning underline that these stock assessment results are data driven instead of methodology driven.

6.6.5 Long term prediction

6.6.5.1 Justification

Yield per recruit analysis was conducted in the STECF EWG 11-20 assuming equilibrium conditions.

6.6.5.2 Input parameters

Yield per recruit analyses was conducted based on the exploitation pattern resulting from the XSA model and population parameters, Minimum and maximum age for the analysis were considered to be age group 0 and 4, respectively. Stock weight at age, catch weight at age and maturity ogive were estimated as mean values on a long term basis (2000-2008). Different natural mortality values were applied per age group but constant for all years based on ProBiom (Abella *et al.*, 1997) as recommended in the report of the SG-ECA/RST/MED 09-01. Fishing mortalities were estimated in a short term basis (2004-2008). Reference F was considered to be mean F for ages 1 to 3. Input parameters are shown in Table 6.6.5.2.1.

Table 6.6.5.2.1. Input parameters for Y/R analysis.

age group	stock weight	catch weight	maturity	F	M
0	0.007	0.008	0	0.00179083	1.50
1	0.010	0.014	0.65	0.18820382	1.00
2	0.013	0.016	0.99	1.12397886	0.74
3	0.017	0.017	1	0.45394309	0.66
4	0.028	0.028	1	0.45394309	0.70

6.6.5.3 Results

Y/R analyses were performed (Fig. 6.6.5.3.1) but were not considered reliable due to its flat-topped shape. Therefore, $F_{0.1}$ (1.37) cannot be used as a reference point for this stock.

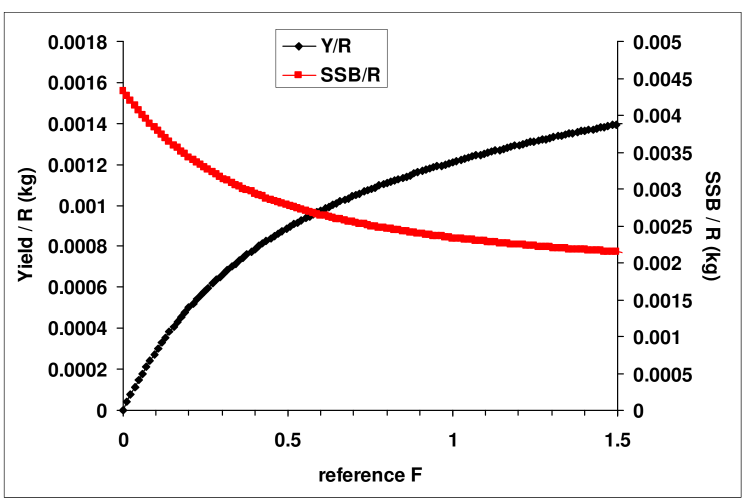


Fig. 6.6.5.3.1. Yield per recruit for the anchovy stock in GSA 22.

6.6.6 Scientific advice

6.6.6.1 Short term considerations

6.6.6.1.1 State of the spawning stock size

Estimates of fishery independent surveys for anchovy in GSA 22 indicated a slight increase from lower levels in 2005 to the most recent estimates in 2006 and 2008 concerning both Total Biomass (62,604 t in 2006 and 60,600 t estimated by acoustics) and SSB (48,700 t in 2006 and 37,400 in 2008 t estimated by DEPM). Results of the XSA analysis indicated an increasing trend in total biomass and in SSB showing up to 2004 followed by a decrease since and increasing again in 2008 well above the lowest levels observed in 2005. The state of the spawning biomass in relation to precautionary limits cannot be evaluated since there are no reference points derived form the short series of data available. However the level of anchovy SSB in 2008 is well above the lowest SSB level (in 2005) observed.

It should be considered that this assessment is based on a short time series of data and not suitable to suggest reference points of B_{lim}. Moreover, anchovy is a short lived species characterized by high fluctuations in abundance and recruitment strongly depends on environmental conditions.

6.6.6.1.2 State of recruitment

XSA model estimates had shown an increase in the number of recruits towards 2008.

6.6.6.1.3 State of exploitation

Based on XSA results, the mean F (for ages 1 to 3) showed a mean for the 2000-2008 equal to 0.38 being well below the exploitation reference points (E<0.4, Patterson (1992)) suggested by STECF EWG 11-20 as an appropriate target reference for small pelagics.

Furthermore, due to the high values of natural mortality used, Y/R analysis indicated no significant reduction in SSB at high values of F. Therefore the use of F_{max} and $F_{0.1}$ as a reference point was not considered appropriate. Precautionary the use of $F_{(E0.4)}$ that assures exploitation rate below the empirical level for stock decline (E<0.4, Patterson (1992)) for small pelagics was suggested by the STECF EWG 11-20 as exploitation reference point for this stock.

Based on this assessment results the stock is considered to be harvested sustainably, operating below but close to an optimal yield level, with no expected room for further increase in catch and effort. STECF EWG 11-20 recommends that fishing effort should not increase beyond the current levels and consistent catches should be determined. This should allow maintaining the current levels of fishing mortality. However this has to be confirmed in following years and the anchovy stock should be monitored on an annual basis. Mixed fisheries implications, i.e. the interaction with sardine, need to be considered when managing this fishery.

For precautionary reasons the possibility of changing the closed period should be examined. Since the fishery is considered a multispecies targeting both anchovy and sardine, a shift of the closed period (present: mid December to end of February) towards the recruitment period of anchovy (e.g. October to December) / or the recruitment period of sardine (e.g. February to April) could be suggested allowing more individuals of anchovy and/or sardine to enter the fishery at an older age.

7 ToR F Short term, medium term and long term forecasts of stock size and yield

The following section of the present report does provide short term, medium term and long term forecasts of stock biomass and yield for the stocks assessed under different management options with a view to evaluate the consequences for fishing effort/mortality changes on equivalent time scale, by fishery/métier and fleets. The predictions of different stocks are presented in a geographic order by GSA, and not by species.

Most of the forecasts have been performed using FLR code. The Annex III illustrates a sample code used for Hake in GSA 9 and that was adapted for the other stocks and GSAs.

7.1 European hake (*Merluccius merluccius*) in GSA 1

Species common name:	European hake
Species scientific name	*Merluccius merluccius*
Geographical Sub-area(s) GSA(s):	GSA 1

7.1.1 Short term prediction 2011-2013

7.1.1.1 Method and justification

A deterministic short term prediction for 2011 to 2013 was performed using the EXCEL workbook provided by JRC (H.-J. Rätz) which takes into account the catch and landings in numbers and weight and the discards, and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) stock assessment performed during EWG11-12. Hake in GSA 1 was assessed though XSA for the first time during that EWG meeting.

7.1.1.2 Input parameters

The following data have been used to derive the input data for the short term projection of the hake stock in GSA 1:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4	gp+
2010	Prop. Matures	0	0.15	0.82	0.98	1	1

PERIOD	Age	0	1	2	3	4	gp+	Mean 0-2
2010	M	1.24	0.61	0.48	0.43	0.4	0.38	0.78

F vector

F	0	1	2	3	4	gp+
2010	0.0736	1.3854	1.5403	2.4137	1.3766	1.3766

Since F increased during 2008- 2010, F in 2010 was re-scaled and these values were taken as input for the short-term prediction. F_{stq} (F_{bar} ages 0-2) was calculated from the rescaled values. These short term predictions were done without taking into account the change in the mesh as adopted by Council Regulation (EC) No 1967/2006 of 21 December 2006.

Weight-at-age in the stock

Mean weight in stock (kg)	0	1	2	3	4	gp+
2010	0.032	0.156	0.461	1.074	1.736	2.894

Weight-at-age in the catch

Mean weight in catch (kg)	0	1	2	3	4	gp+
2010	0.032	0.156	0.461	1.074	1.736	2.894

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2	3	4	gp+
2010	303	2818	602	70	3	0

Number at age in the stock

Numbers at age in the stock (thousands)	0	1	2	3	4	gp+
2010	6624	4939	1009	102	5	0

Stock recruitment

Recruitment (class 0+) has been estimated as the geometric mean from 2002 to 2009 (from XSA done in SGMED 10-02; this assessment regards bottom trawl exclusively).

7.1.1.3 Results

Short-term implications

A short term projection (Table 7.1.1.3.1), assuming an F_{stq} of 1.0 in 2011 and a recruitment of 12102 (thousand) individuals, shows that:

- Fishing at the F_{stq} (1.0) from 2010 to 2012 would generate a high increase of the catches in 2012, while the spawning stock biomass would also increase between 2012 to 2013.
- Fishing at $F_{0.1}$ (0.16) from 2010 to 2012 generates a decrease of the catches of 59% in 2012 and a spawning stock biomass increase by 355% from 2012 to 2013.
- STECF EWG 11-20 recommends that catch in 2012 should not exceed 315 tons, corresponding to $F_{0.1}$ = 0.16.

Outlook until 2013

Table 7.1.1.3.1. Short term forecast for different F scenarios computed for hake in GSA 1.

Basis: F(2011) = mean (Fbar 0-2, re-scaled 2008-2010); R(2011) = GM (2003-2010) = 12102 (thousands); F (2011) = 0.998; SSB (2011) = 448 t; landings(2010)= 509. Weights in tons.

Rationale	F scenario	F factor	Catch 2012	Catch 2013	SSB 2013	Change SSB 2012-2013 (%)	Change Catch 2010-2012 (%)
zero catch	0.00	0.00	0	0	2710	466.9	-100.0
High long-term yield ($F_{0.1}$)	0.16	0.16	315	538	2175	355.0	-59.6
Status quo	1.00	1.00	1240	836	715	49.6	59.2
Different scenarios	0.10	0.10	206	378	2363	394.4	-73.6
	0.20	0.20	383	627	2062	331.4	-50.8
	0.30	0.30	541	780	1796	275.7	-30.6
	0.40	0.40	680	869	1569	228.2	-12.7
	0.50	0.50	804	912	1373	187.2	3.2
	0.60	0.60	912	922	1201	151.3	17.1
	0.70	0.70	1012	917	1052	120.1	29.9
	0.80	0.80	1097	897	923	93.1	40.8
	0.90	0.90	1172	866	812	69.9	50.4
	1.10	1.10	1299	802	632	32.2	66.8
	1.20	1.20	1357	768	558	16.7	74.2
	1.30	1.30	1405	736	494	3.3	80.4
	1.40	1.40	1447	702	436	-8.8	85.8
	1.50	1.50	1487	672	389	-18.6	90.9
	1.60	1.60	1522	647	348	-27.2	95.4
	1.70	1.70	1553	623	311	-34.9	99.4
	1.80	1.80	1582	601	279	-41.6	103.1
	1.90	1.90	1608	581	251	-47.5	106.4
	2.00	2.00	1633	563	227	-52.5	109.6

Comparison between the short- term forecast delivered previously

Since hake in GSA 1 was assessed for the first time during STECF EWG11-12 no comparison can be made between the observed values in 2010 and predicted values.

This fishery is highly dependent on recruitment. The very high increase in both catches and SSB in the short term with *status quo* could be explaines by the constant recruitment values used as input for the prediction in

2011 and 2012, which are relatively high when compared with recruitment in 2010.

7.1.2 Medium term prediction

7.1.2.1 Method and justification

Medium term predictions from 2010 to 2020 were implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994). Four scenarios of F reduction were considered. As in the short- term prediction, constant recruitment was assumed (i.e. geometric mean recruitment over 2003- 2010). Runs were made with 500 simulations per run.

The scenarios were the following:

1: Constant F = $F_{0.1}$
2: 10% reduction in F per annum
3: Hit F = $F_{0.1}$ by 2015, then fix at F = F0.1
4: Linear decrease in F to reach F = $F_{0.1}$ in 2020

7.1.2.2 Input parameters

Input parameters (maturity ogive, M, weight-at-age for the stock and for the catch) were the same as in the short- term prediction. Stock numbers at-age and F at- age over 2003-2010 were taken from the XSA results.

7.1.2.3 Results

In all 4 scenarios SSB responds very quickly to the decrease in F, which is to be expected since the hake fishery in GAS 1 is highly dependent on recruitment and the age of maturity is two years. Scenarios 1 and 3 correspond to a much quicker F decrease (forced to F0.1 already in 2012 or in 2015). Consequently, both SSB and Yield are higher in 2020 than in scenarios 2 and 4. A linear decrease in F to reach $F_{0.1}$ in 2020 (scenario 4) would not result in an increase in yield in the mid-term.

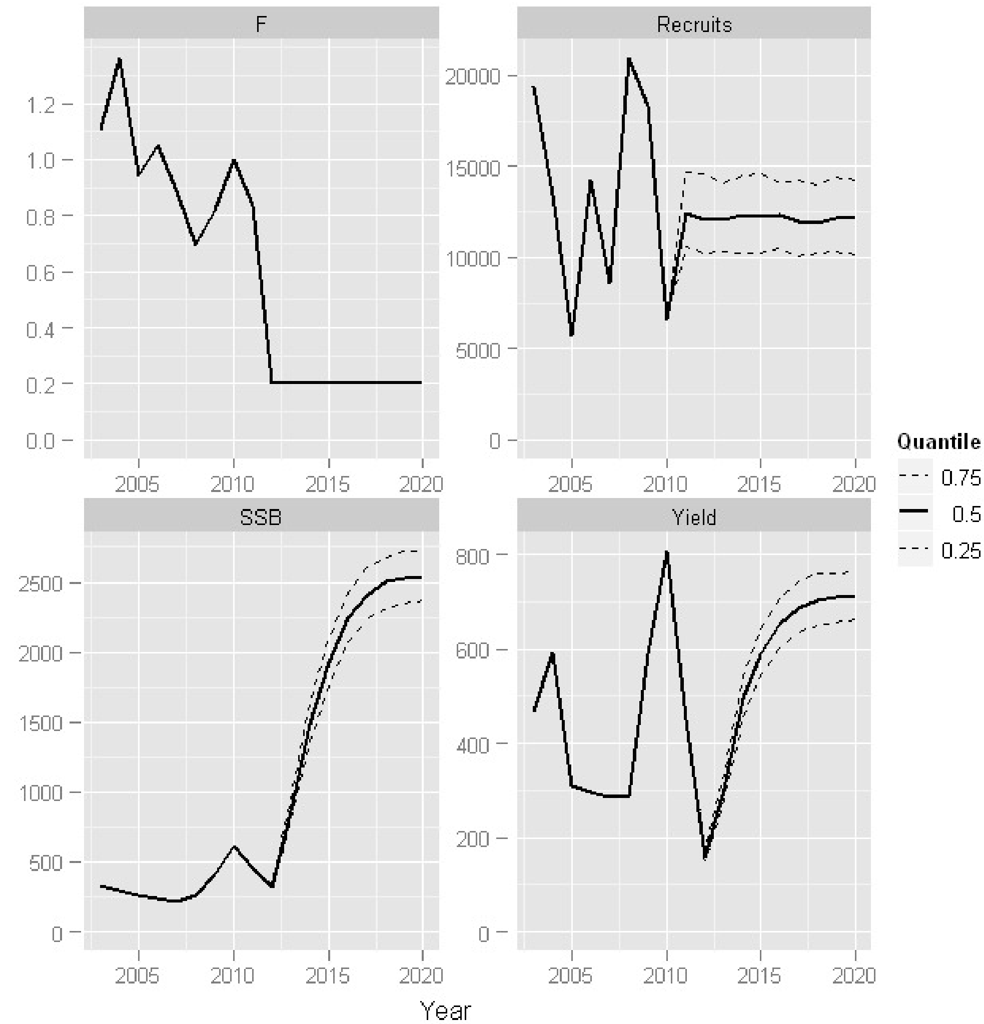


Fig. 7.1.2.3.1. Medium term predictions. Scenario 1: constant F = $F_{0.1}$.

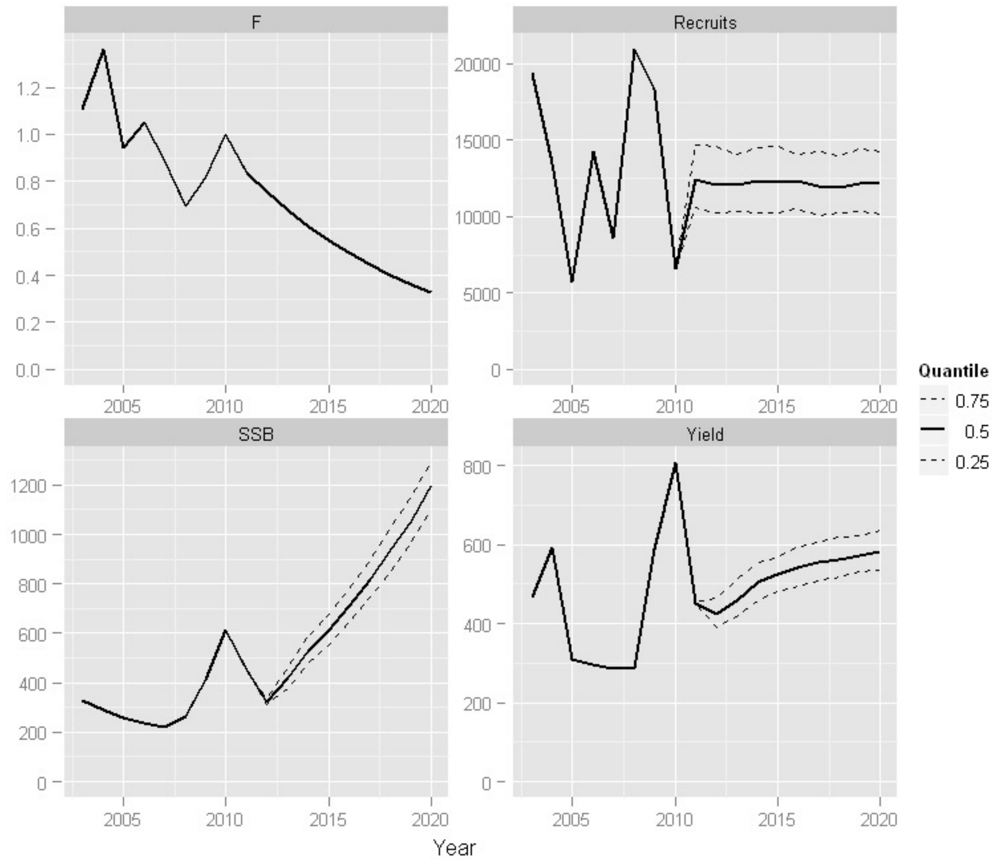


Fig. 7.1.2.3.2. Medium term predictions. Scenario 2: 10% reduction in F per year.

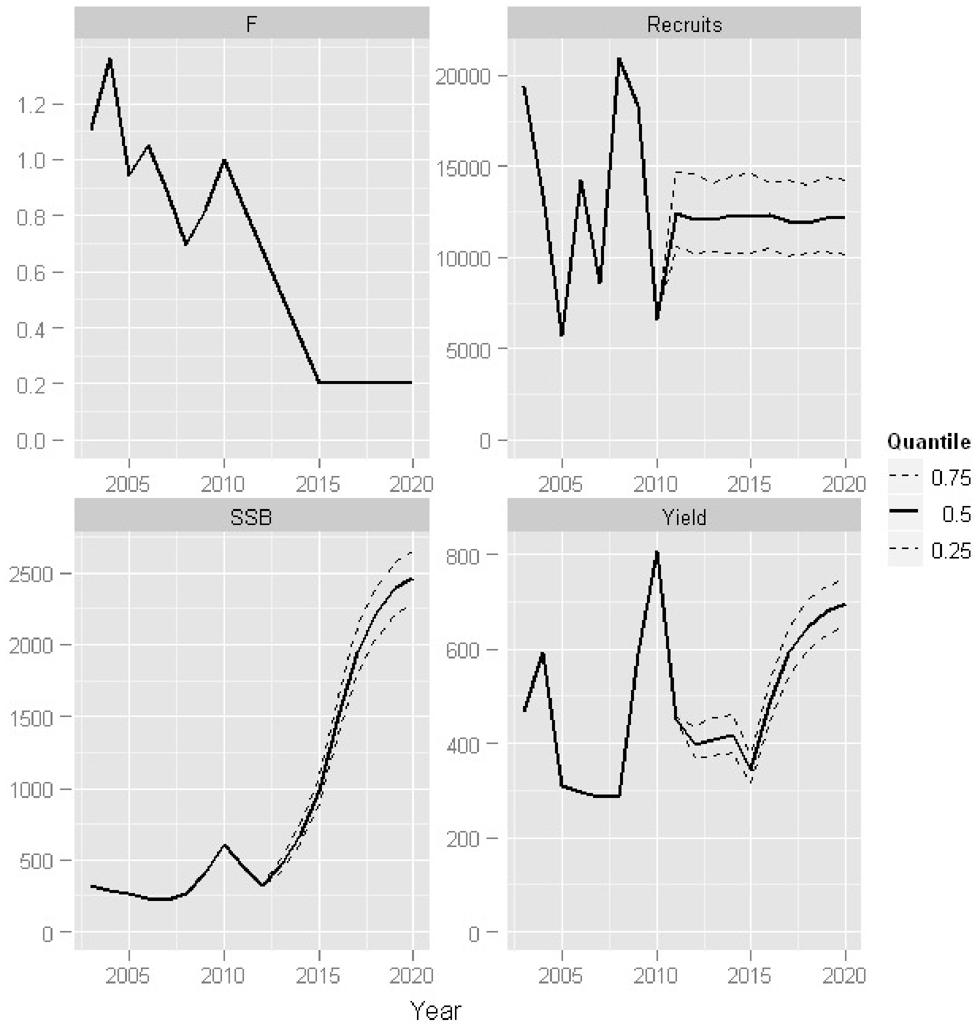


Fig. 7.1.2.3.3. Medium term predictions. Scenario 3: Reach F = $F_{0.1}$ by 2015, then fix at F = $F_{0.1}$.

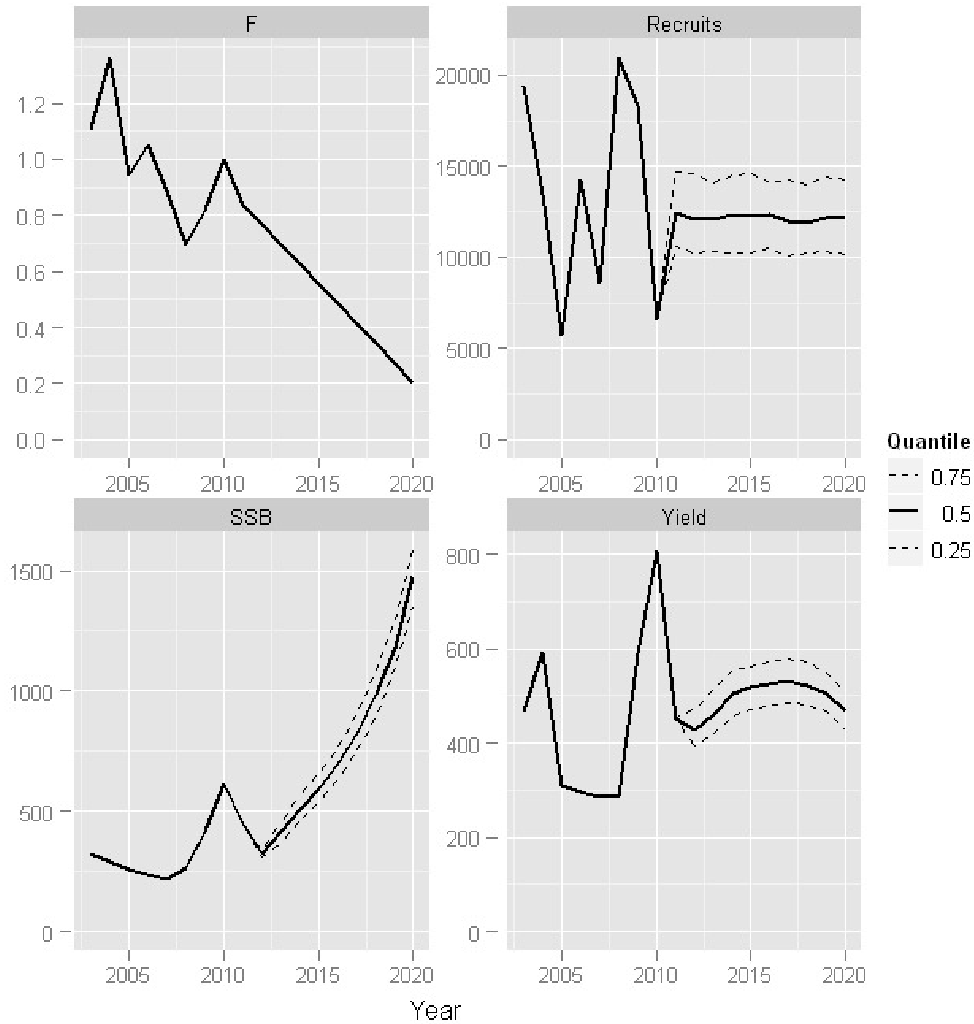


Fig. 7.1.2.3.4. Medium term predictions. Scenario 4: Linear decrease in F to reach F = $F_{0.1}$ in 2020.

7.2 Red mullet (*Mullus barbatus*) in GSA 01

7.2.1 Short term prediction 2011-2013

7.2.1.1 Method and justification

A deterministic short term prediction for 2011 to 2013 was performed using the EXCEL workbook provided by JRC IPSC (H.-J. Rätz) which takes into account the catch and landings in numbers and weight and the discards, and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) performed for the first time during SGMED-11-02.

7.2.1.2 Input parameters

The following data have been used to derive the input data for the short term projection of the red mullet stock in GSA 1:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4+
2010	Prop. Matures	0.46	0.76	1	1	1

PERIOD	Age	0	1	2	3	4+
2010	M	1.03	0.47	0.35	0.3	0.27

F vector

F	0	1	2	3	4+
2010	0.05	1.52	2.21	1.29	1.29

Several scenarios with different harvest strategy were run, with F_{stq} (F_{bar} ages 1-2) calculated as the average of the last 3 years (2008-2010), but scaled to the F of 2010 in order to account for the recent trend in the fishing mortality pattern.

Potential changes in selectivity due to the implementation of the 40mm square / 50mm diamond mesh size on trawlers based on EC 1967/2006 were not taken into account in the predictions.

Weight-at-age in the stock

Mean weight in stock (kg)	0	1	2	3	4+
2010	0.080	0.029	0.077	0.135	0.229

Weight-at-age in the catch

Mean weight in catch (kg)	0	1	2	3	4+
2010	0.080	0.029	0.077	0.135	0.229

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2	3	4+
2003	0	1281	612	168	58
2004	28	2410	383	24	0
2005	3	1928	499	20	0
2006	164	2516	402	29	1
2007	110	3120	531	17	0
2008	234	3073	602	34	5
2009	207	3714	848	86	5
2010	1226	3385	620	48	3

Number at age in the stock

Stock at age in numbers (thousands)	0	1	2	3	4+
2003	11492	2427	785	266	87
2004	9213	4103	504	39	0
2005	12170	3272	659	33	0
2006	15419	4343	521	46	2
2007	16082	5407	725	30	0
2008	17266	5676	912	65	10
2009	15735	6024	1118	137	7
2010	26223	5494	829	76	4
2011	14779*	8629	758	64	16

Stock recruitment

Recruitment (class 0) in 2011 (*) has been estimated as the geometric mean from 2003 to 2010 class 0 (from XSA done in EWG-11-02; this assessment consider catches from bottom trawl and trammel net).

7.2.1.3 Results

A short term projection (Table 7.2.1.3.1), assuming an F_{stq} of 1.86 in 2010 and a recruitment of 14779 (thousands) individuals, shows that:

- Fishing at the F_{stq} (1.86) from 2010 to 2012 would generate an increase of the catches of 4.5% in 2012, while the spawning stock biomass would decrease by 4.5% between 2012 and 2013.
- Fishing at $F_{0.1}$ (0.3) from 2010 to 2012 generates a decrease of the catches of 73% in 2012 and a spawning stock biomass increase by 24% from 2012 to 2013.
- EWG 11-20 recommends that landings in 2012 should not exceed 54 t, corresponding to $F_{0.1}$= 0.30.

Outlook until 2013

Table 7.2.1.3.1. Short term forecast for different F scenarios computed for red mullet in GSA 1.

Basis: F(2011) = mean(F_{bar}1-2 2010); R (2011) = GM (2003-2010) = 14779 (thousands); F_{stq} (2011) = 1.86; SSB (2011) = 805 t; landings (2011)= 253 t. Weights in tons.

Rationale	F scenario	F factor	Catch 2012	Catch 2013	SSB 2013	Change SSB 2012-2013 (%)	Change Catch 2010-2012 (%)
zero catch	0.00	0.00	0	0	1026	35.5	-100.0
High long-term yield ($F_{0.1}$)	0.30	0.16	54	93	936	23.6	-73.0
Status quo	1.86	1.00	209	181	723	-4.5	4.5
Different scenarios	0.19	0.1	36	65	967	27.7	-82.0
	0.37	0.2	68	110	918	21.3	-66.0
	0.56	0.3	94	137	878	16.0	-53.0
	0.75	0.4	117	154	843	11.4	-41.5
	0.93	0.5	138	166	814	7.5	-31.0
	1.12	0.6	156	172	790	4.4	-22.0
	1.31	0.7	171	176	769	1.6	-14.5
	1.49	0.8	186	180	750	-0.9	-7.0
	1.68	0.9	198	181	736	-2.8	-1.0
	2.05	1.1	219	183	713	-5.8	9.5
	2.24	1.2	229	183	703	-7.1	14.5
	2.42	1.3	237	184	696	-8.1	18.5
	2.61	1.4	244	185	689	-9.0	22.0
	2.80	1.5	250	186	683	-9.8	25.0
	2.98	1.6	258	189	677	-10.6	29
	3.17	1.7	265	190	674	-11.0	32.5
	3.36	1.8	271	191	670	-11.5	35.5
	3.54	1.9	275	192	668	-11.8	37.5
	3.73	2.0	282	195	664	-12.3	41

Comparison between the short-term forecast delivered previously

Since red mullet in GSA01 was assessed for the first time during STECF EWG 11-02, no comparison can be made between the observed values in 2010 and predicted values.

7.2.2 *Medium term prediction*

7.2.2.1 Method and justification

Medium term predictions from 2010 to 2020 were implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) performed during STECF EWG 11-12. As in the short- term prediction, constant recruitment was assumed. For the stock-recruitment relationship it has used geometric mean recruitment over the whole data period (2003-2010). Runs were made with 500 simulations per run.

Four scenarios were conducted for red mullet in GSA1. These scenarios consider different cases of F reduction:
1: constant F = F0.1
2: 10% reduction in F per year
3: Hit F = F0.1 by 2015, then fix at F = F0.1
4: Linear decrease in F to hit F = F0.1 in 2020

7.2.2.2 Input parameters

The input parameters (maturity ogive, M, weight-at-age for the stock and for the catch) were the same as in the short term forecast. Stock numbers at-age and F at- age over 2003-2010 were taken from the XSA results.

7.2.2.3 Results

Figures 7.2.2.3.1 to 7.2.2.3.4 show the results of medium term predictions for 10 years until 2020 in the four different scenarios.

The decrease in fishing mortality values to the $F_{0.1}$ from 2011 to 2020 determines in all scenarios an increasing trend of the SSB, from 300 t in 2010 to 400-500 t in 2020 depending on scenarios. Catches in all scenarios reach similar values at the end of the period (2020) to the values observed in 2003-2010.

In the case of red mullet on GSA1 the highest landings and SSB correspond to scenarios 1 and 3, with SSB values of around 500 tons and yields around 200 tons.

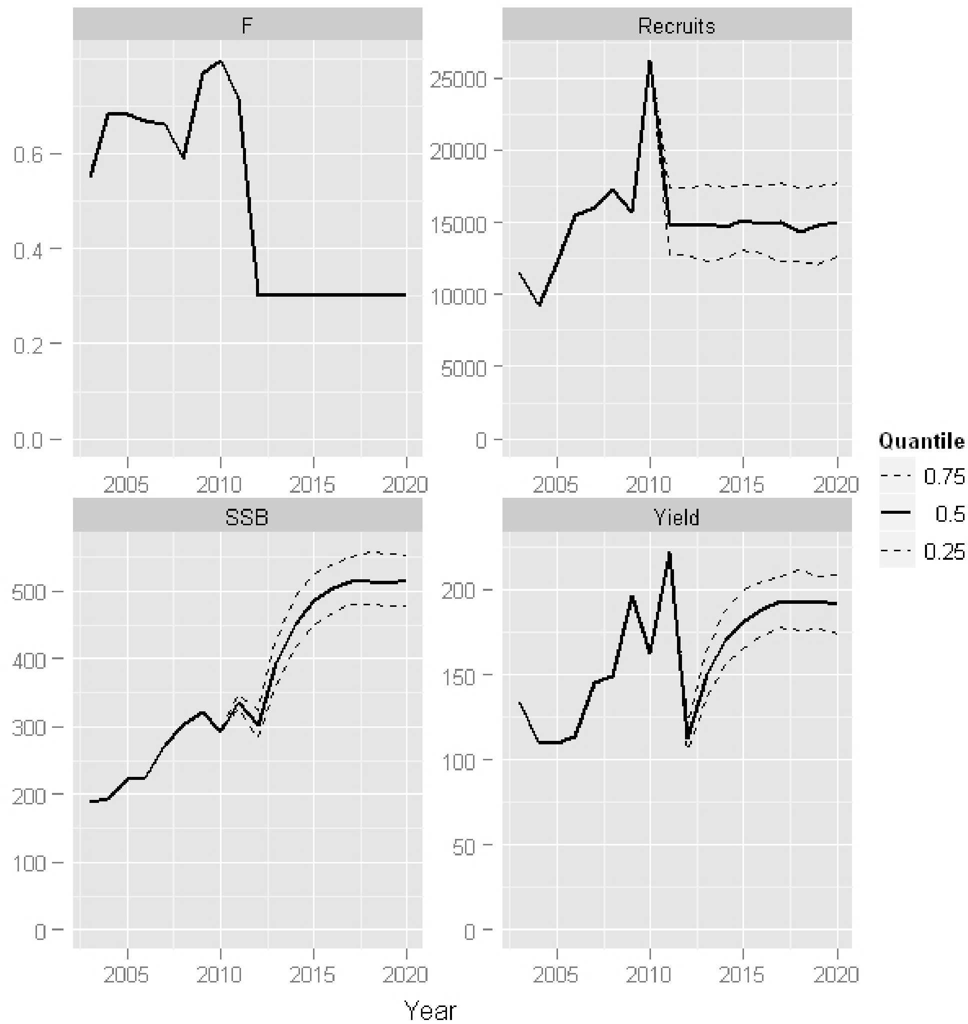


Fig. 7.2.2.3.1. Scenario 1: constant F = $F_{0.1}$. Medium term predictions for F, Recruits, SSB and catch.

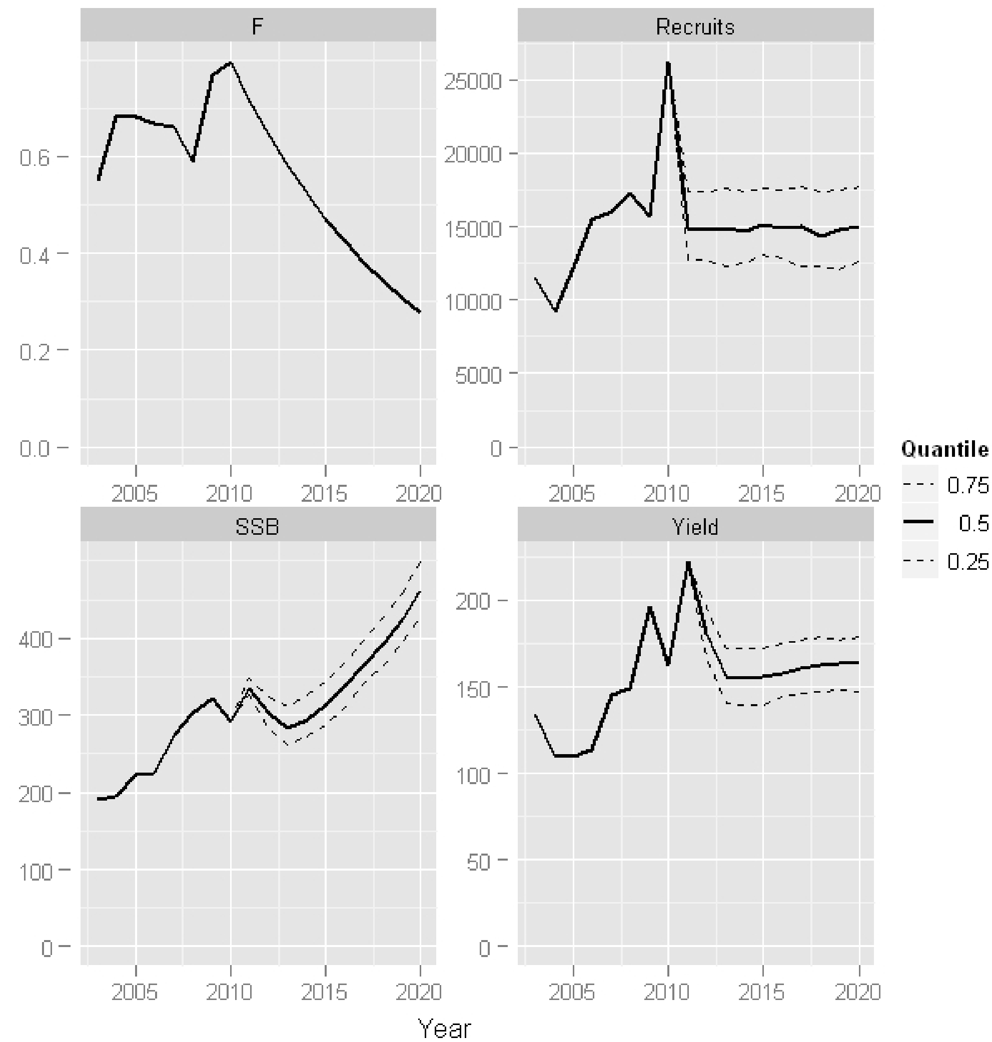


Fig. 7.2.2.3.2. Scenario 2: 10% reduction in F per year. Medium term predictions for F, recruits, SSB and catch.

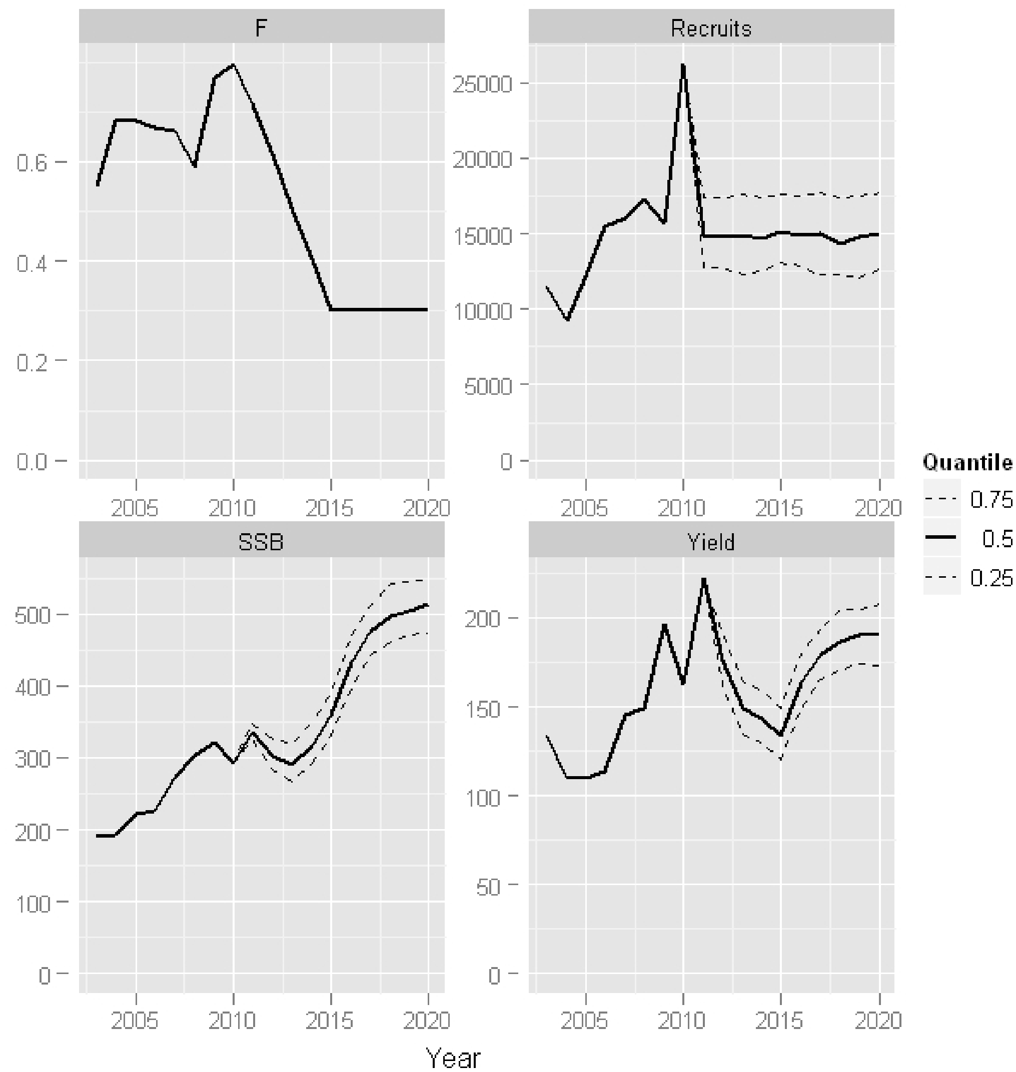


Fig. 7.2.2.3.3. Scenario 3: Reach F = $F_{0.1}$ by 2015, then fix at F = $F_{0.1}$. Medium term predictions for F, recruits, SSB and catch.

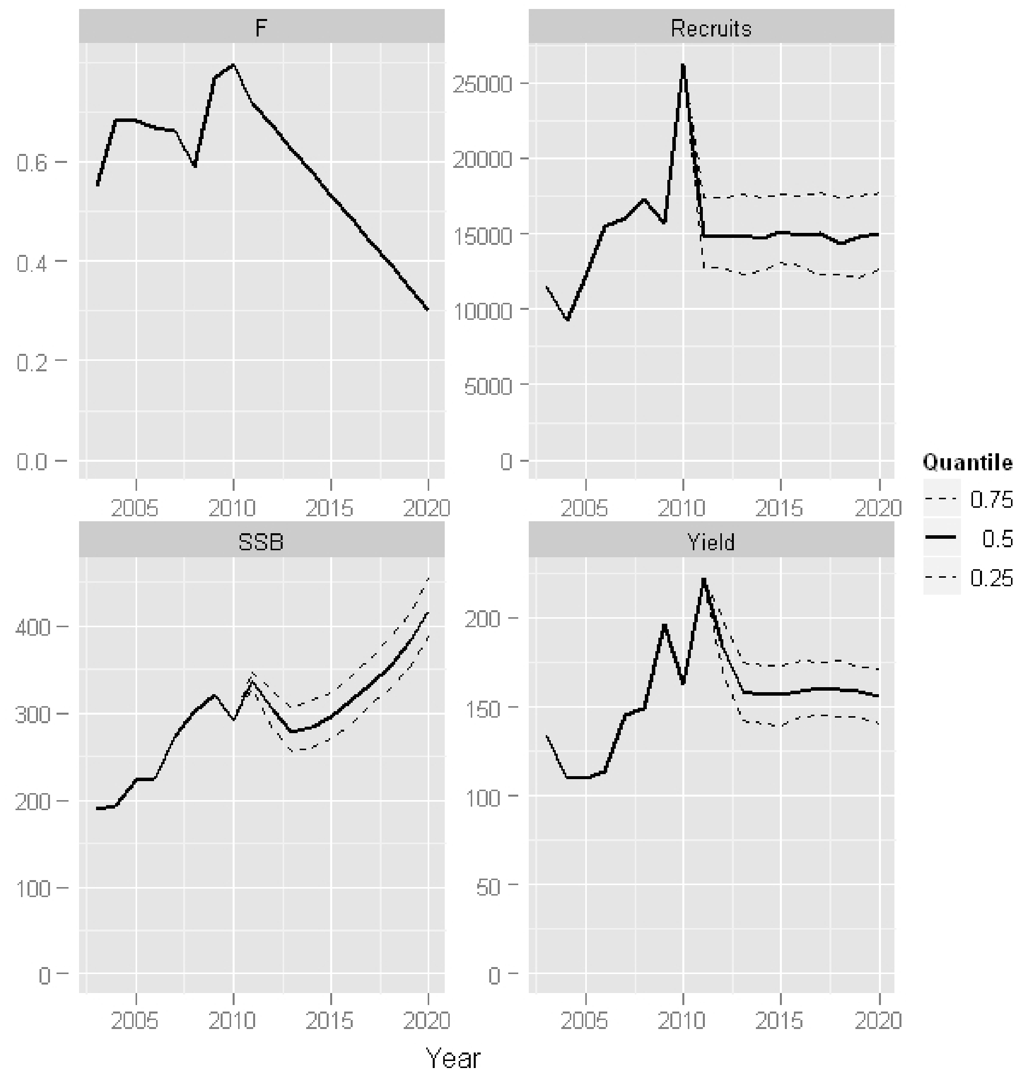


Fig. 7.2.2.3.4. Scenario 4: Linear decrease in F to reach F = $F_{0.1}$ in 2020. Medium term predictions for F, recruits, SSB and catch.

7.3 European hake (*Merluccius merluccius*) in GSA 5

7.3.1 Short term prediction 2011-2013

7.3.1.1 Method and justification

A deterministic short term prediction for 2011 to 2013 was performed using FLR (www.r-project.org), which take into account the catch and landings in numbers and weight based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994). Stock assessment of this stock was presented at the GFCM 2011 and revised during the current EWG 11-20 meeting.

7.3.1.2 Input parameters

The following data have been used to derive the input data for the short term projection of the hake stock in GSA 5:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4	5+
2007-2010	Prop. Matures	0	0.05	0.56	0.89	0.98	1

PERIOD	Age	0	1	2	3	4	5+	Mean 0-4
2007-2010	M	1	0.70	0.50	0.40	0.40	0.40	0.60

F vector

F	0	1	2	3	4	5+
2010	0.125	1.866	2.023	1.122	1.505	1.505

Weight-at-age in the stock

Mean weight in stock (kg)	0	1	2	3	4	5+
2007-2010	0.024	0.098	0.378	0.972	1.666	2.750

Weight-at-age in the catch

Mean weight in catch (kg)	0	1	2	3	4	5+
2007-2010	0.024	0.098	0.378	0.972	1.666	2.750

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2	3	4	5+
2010	218.2	709.6	102.2	4.0	1.8	0.1

Number at age in the stock

Stock at age in numbers (thousands)	0	1	2	3	4	5+
2011	3623.6*	1161.9	145.3	7.0	2.7	0.1

Different scenarios of constant harvest strategy with reduction of the mean F (F_{bar} ages 0-4) calculated as the average ages 0 to 4 in 2010 was used and defined as F status quo (F_{stq} = 1.26).

Stock recruitment

*Recruitment (class 0) has been estimated as the geometric mean of the last 3 years.

7.3.1.3 Results

Short-term implications

A short term projection (Table 7.3.1.3.1), assuming an F_{stq} of 1.26 in 2011 and a recruitment of 3623 (thousand) individuals, shows that:

- Fishing at the F_{stq} (1.26) generates a decrease of the catch of 11.6% from 2010 to 2012 along with an increase of the spawning stock biomass of 5% from 2012 to 2013.

- Fishing at $F_{0.1}$ (0.14) for the same time frame (2010-2013) generates a decrease of the catch of 83% in 2011 and a spawning stock biomass increase of 264% from 2012 to 2013.

Outlook until 2013

Table 7.3.1.3.1. Short term forecast in different F scenarios computed for hake in GSA 5.

Basis: F(2011) = mean(F_{bar} 0-4 2010); Catch (2011): 100.6 t; R(2011) = 3623 (thousands); F (2011) = 1.328; SSB(2012) = 39.2 t. Weights in tons.

Rationale	F scenario	F factor	Catch 2012	Catch 2013	SSB 2013	Change SSB 2012-2013 (%)	Change Catch 2010-2012 (%)
zero catch	0.00	0.00	0	0	196	332.6	-100.0
High long-term yield ($F_{0.1}$)	0.1403	0.15	21	49	164	264.1	-83.0
Status quo	1.2610	1.00	109	113	42	5.1	-11.6
Different scenarios	0.1261	0.1	19	45	167	270.5	-84.6
	0.2522	0.2	35	74	142	217.9	-71.3
	0.3783	0.3	50	93	121	173.5	-59.8
	0.5044	0.4	62	104	103	136.0	-49.8
	0.6305	0.5	73	111	88	104.2	-41.1
	0.7567	0.6	82	114	76	77.3	-33.5
	0.8828	0.7	90	115	65	54.5	-26.9
	1.0089	0.8	97	115	56	35.3	-21.1
	1.1350	0.9	104	114	48	18.9	-16.0
	1.3872	1.1	114	111	36	-6.7	-7.6
	1.5133	1.2	118	109	31	-16.6	-4.1
	1.6394	1.3	122	107	27	-25.1	-0.9
	1.7655	1.4	126	106	24	-32.2	1.9
	1.8916	1.5	129	104	21	-38.3	4.4
	2.0177	1.6	132	103	19	-43.5	6.7
	2.1438	1.7	134	102	17	-47.9	8.7
	2.2700	1.8	137	100	15	-51.7	10.6
	2.3961	1.9	139	99	13	-54.9	12.3
	2.5222	2	141	99	12	-57.6	13.9

7.3.2 Medium term prediction

7.3.2.1 Method and justification

Medium term prediction from 2011 to 2020 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) performed using the Lowestoft software suite, which were presented at the GFCM 2011. Four different assumptions were used in the medium term projections (10 years): 1) constant $F=F_{0.1}$; 2) 10% reduction in F per year; 3) decrease from F_{stq} to $F=F_{0.1}$ by 2015, then constant $F_{0.1;}$ 4) linear decrease in F to reach $F=F_{0.1}$ in 2020. The stock-recruitment relationship used geometric mean recruitment of the last 3 years (2008-2010).

7.3.2.2 Input parameters

The maturity ogive, the natural mortality, the numbers of individuals and weight-at-age for the stock and for the catch were the same used in the short term forecast.

7.3.2.3 Results

SSB increases sharply in all four scenarios, although scenarios 1 and 3 reach 1000-1200 tons in 2020 whereas scenarios 2 and 4 only reach 200 and 400 tons respectively. In scenarios 1 and 3, yields also decrease sharply during the first years but increase at similar rates afterwards up to 200 tons in 2020. Yields in scenario 2 do not decrease but only increase up to about 130 tons in 2020. Yields in scenario 4 do not show great variations during the first years, but decrease sharply down to 70 tons in 2020.

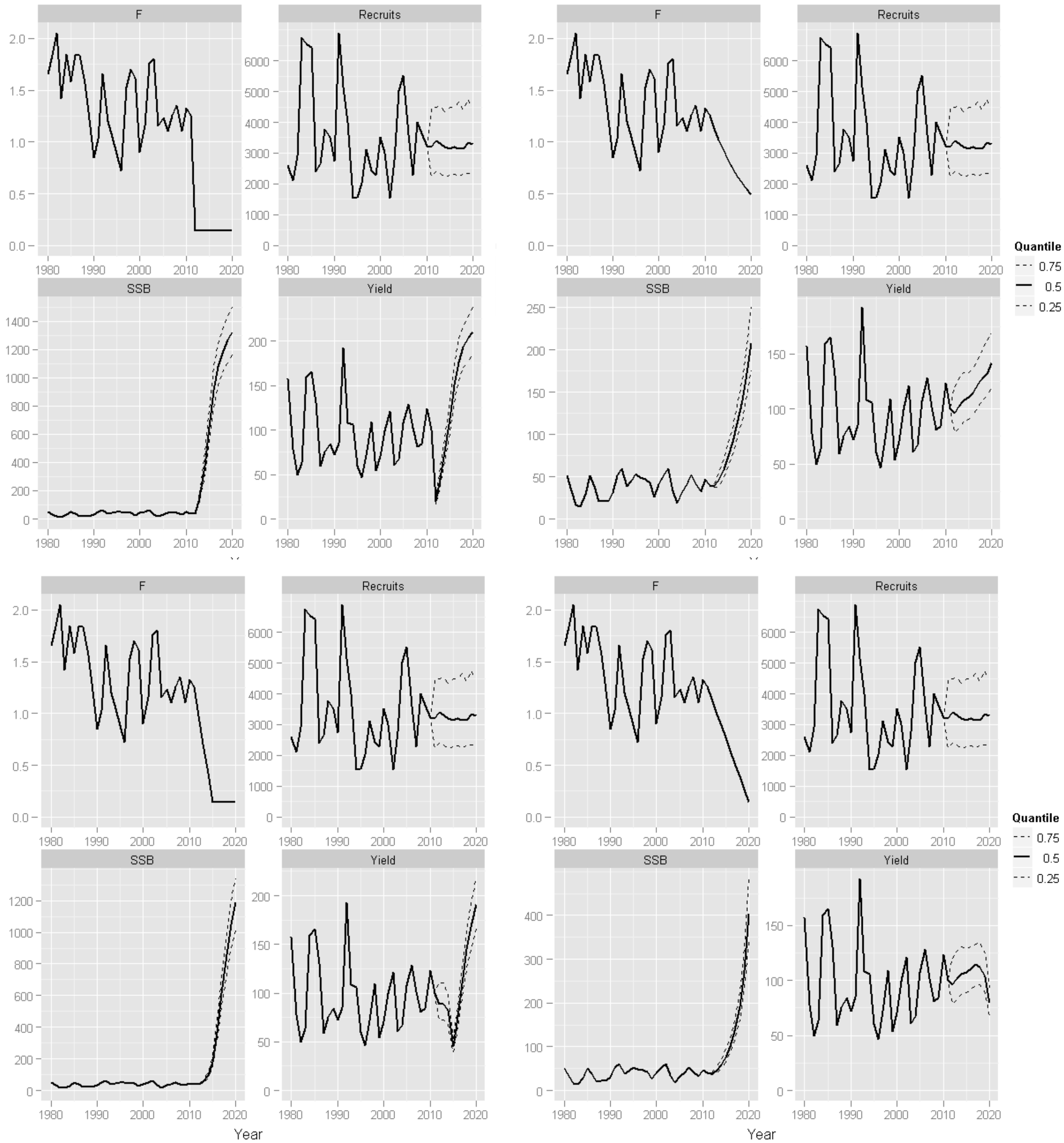


Figure 7.3.2.3.1. Outputs of the four medium term forecast computed for striped mullet in GSA 5 under different scenarios: 1) constant $F=F_{0.1}$; 2) 10% reduction in F per year; 3) decrease from F_{stq} to $F=F_{0.1}$ by 2015, then constant $F_{0.1;}$ 4) linear decrease in F to hit $F=F_{0.1}$ in 2020.

7.4 Striped red mullet (*Mullus surmuletus*) in GSA 5

7.4.1 Short term prediction 2011-2013

7.4.1.1 Method and justification

A deterministic short term prediction for 2011 to 2013 was performed using FLR (www.r-project.org), which take into account the catch and landings in numbers and weight based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994). Stock assessment of this stock was presented at the GFCM 2011 and revised by the EWG 11-20 meeting.

7.4.1.2 Input parameters

The following data have been used to derive the input data for the short term projection of the striped red mullet stock in GSA 5:

Maturity

Period	Age	0	1	2	3	4	5
2000-2010	Prop. Matures	0.15	0.39	0.79	0.95	1	1

M vector

Period	Age	0	1	2	3	4	5
2000-2010	M	1	0.6	0.4	0.3	0.3	0.3

F vector

F	0	1	2	3	4	5
2010	0.082	0.728	0.993	0.751	0.746	0.746

Weight-at-age in the stock

Mean weight (kg)	0	1	2	3	4	5
2008-2010	0.027	0.054	0.092	0.140	0.191	0.274

Weight-at-age in the catch

Mean weight (kg)	0	1	2	3	4	5

2008-2010	0.027	0.054	0.092	0.140	0.191	0.274

Number at age in the stock

N (thousands)	0	1	2	3	4	5
2011	6451.5*	1794.7	812.0	276.6	63.0	19.7

Different scenarios of constant harvest strategy with reduction of the mean F calculated as the average ages 1 to 4 in 2010 was used and defined as F status quo (F_{stq} = 0.792).

Stock recruitment

*Recruitment (class 0) has been estimated as the geometric mean of the last three years (2008 to 2010).

7.4.1.3 Results

Short-term implications

A short term projection (Table 7.4.1.3.1), assuming an F_{stq} of 0.792 in 2011 and a recruitment of 6451.5 (thousand) individuals, shows that:

- Fishing at the F_{stq} (0.792) generates a catch decrease of 5.8% from 2010 to 2012 along with a SSB decrease of 0.7% from 2012 to 2013.
- Fishing at $F_{0.1}$ (0.273) for the same time frame (2010-2013) generates a catch decrease of 60.6% from 2010 to 2012 and a SSB increase of 32.4% from 2012 to 2013.

The estimated catch of striped red mullet in GSA 5 for 2012 amounts 43.6 tons. Consequently, SGMED recommends that the catch level of 43.6 t not to be exceeded.

Outlook until 2013

Table 7.4.1.3.1. Short term forecast in different F scenarios computed for red mullet in GSA 5.

Basis: F(2011) = mean(F_{bar}1-4 2008-2010); Catch (2011): 101.8 t; R(2011) = GM(2008–2010) = 6451.5 (thousands); F (2010) = 0.805; SSB(2012) = 171.7 t. Weights in tons.

Rationale	F scenario	F factor	Catch 2012	Catch 2013	SSB 2013	Change SSB 2012-2013 (%)	Change Catch 2010-2012 (%)
zero catch	0.00	0.0	0	0	275.4	57.3	-100.0
High long-term yield (F0.1)	0.273	0.35	43.6	58.5	230.3	32.4	-60.6
Status quo	0.792	1	104.2	103.4	170.4	-0.7	-5.8
Different scenarios	0.079	0.1	13.6	20.9	261.1	49.4	-87.7
	0.158	0.2	26.4	38.3	247.9	42.1	-76.1
	0.238	0.3	38.4	52.8	235.6	35.3	-65.3
	0.317	0.4	49.6	64.8	224.1	29.0	-55.1
	0.396	0.5	60.2	74.8	213.5	23.1	-45.6
	0.475	0.6	70.1	83.0	203.6	17.6	-36.6
	0.555	0.7	79.4	89.7	194.4	12.6	-28.2
	0.634	0.8	88.2	95.2	185.8	7.8	-20.3
	0.713	0.9	96.5	99.7	177.9	3.4	-12.8
	0.871	1.1	111.6	106.4	163.5	-4.5	0.9
	0.951	1.2	118.5	108.7	157.0	-8.1	7.1
	1.030	1.3	125.1	110.6	151.0	-11.4	13.0
	1.109	1.4	131.3	112.0	145.4	-14.5	18.6
	1.188	1.5	137.1	113.2	140.1	-17.4	23.9
	1.268	1.6	142.6	114.0	135.2	-20.2	28.9
	1.347	1.7	147.9	114.7	130.6	-22.7	33.7
	1.426	1.8	152.9	115.1	126.3	-25.1	38.2
	1.505	1.9	157.6	115.4	122.3	-27.3	42.5
	1.585	2	162.1	115.6	118.5	-29.4	46.5

7.4.2 Medium term prediction

7.4.2.1 Method and justification

Medium term prediction from 2011 to 2020 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) performed using the Lowestoft software suite for the striped mulled from GSA 5, which were presented at the GFCM 2011 and revised by the EWG 11-20 meeting. Four different assumptions were used in the Medium term projections (10 years): 1) constant F=$F_{0.1}$; 2) 10% reduction in F per year; 3) decrease from F_{stq} to F=$F_{0.1}$ by 2015, then constant $F_{0.1;}$ 4) linear decrease in F to hit F=$F_{0.1}$ in 2020. The stock-recruitment relationship used geometric mean recruitment of the last 3 years (2008-2010).

7.4.2.2 Input parameters

The maturity ogive, the natural mortality, the numbers of individuals and weight-at-age for the stock and for the catch were the same used in the short term forecast.

7.4.2.3 Results

SSB increased sharply from about 200 tons in 2010 to 400 tons in 2020 for scenarios 1 and 3, which showed asymptotic growth during the last years, especially in scenario 1; SSB also increased in scenarios 2 and 4, although not as sharply as in the previous scenarios, and it only reached 350 tons in 2020 (Figure 7.4.2.3.1.).

Yield decreased progressively up to 90 and 80 tons in scenarios 2 and 4. Yield decreased sharply in scenario 1 down to 50 tons in 2012, but increased also sharply up to 100 tons in 2020. Scenario 3 decreased down to 70 tons in 2016 but increased up to 100 tons in 2020.

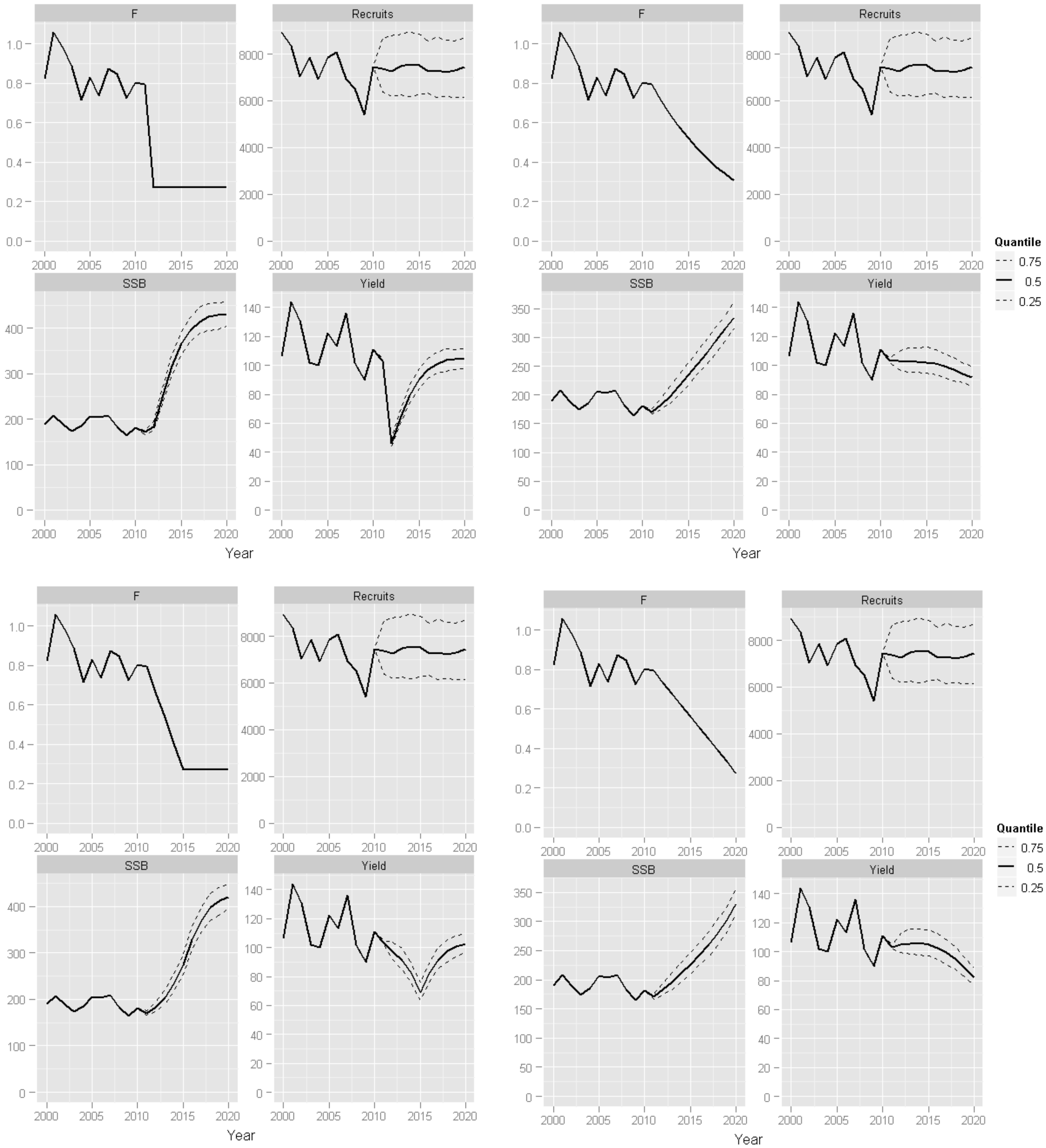


Fig. 7.4.2.3.1. Outputs of the four medium term forecast computed for striped mullet in GSA 5 under different scenarios: 1) constant $F=F_{0.1}$; 2) 10% reduction in F per year; 3) decrease from F_{stq} to $F=F_{0.1}$ by 2015, then constant $F_{0.1;}$ 4) linear decrease in F to hit $F=F_{0.1}$ in 2020.

7.5 European hake (*Merluccius merluccius*) in GSA 6

7.5.1 Short term prediction for 2011 - 2013

7.5.1.1 Method and justification

A deterministic short term prediction for 2011 to 2013 was performed using the EXCEL workbook provided by JRC IPSC (H.-J. Rätz) which takes into account the catch and landings in numbers and weight by Spanish trawlers and gillnetters, and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) stock assessment performed during EWG 11-12). Data from trawlers and gillnetters were pooled together to produce one single forecast. Nevertheless gillnet catch is relatively small (20% of the total landings). Discards were not used because they were very small (816 kg in 2010 compared to 3278 t landed) and because no age or size distributions were provided for these small discards.

7.5.1.2 Input parameters

The following input parameters have been used for the short projection of hake in GSA 06. M and weight at age values are the average 2008-2010 values whereas the F values are the averages 2008-2010 rescaled to 2010 values to take into account the trend in F

Maturity and M vectors

PERIOD	Age	0	1	2	3	4	5+
2010	Prop. Matures	0	0.15	0.82	0.98	1	1

PERIOD	Age	0	1	2	3	4	5	6	7	Mean 0-4
2010	M	1.53	0.61	0.37	0.31	0.28	0.26	0.25	0.24	0.62

F vector

F	0	1	2	3	4	5	6	7
2010	0.71	1.18	1.68	1.73	2.68	1.50	5.22	0

Weight-at-age in the stock

Mean weight in stock	0	1	2	3	4	5	6	7
kg	0.02	0.117	0.453	1.149	1.752	2.791	3.773	4.332

Weight-at-age in the catch

Mean weight in catch	0	1	2	3	4	5	6	7

kg	0.02	0.111	0.477	1.091	1.818	2.455	3.690	4.540

Number at age in the catch

Catch at age in numbers (x 1000)	0	1	2	3	4	5	6	7
2010	45796	9944	3016	465	60	1	0	0

Number at age in the stock

Numbers at age in the stock (x 1000)	0	1	2	3	4	5	6	7
2010	194484	19405	4461	658	74	2	0	0

Different scenarios of constant harvest strategy with reduction of the mean F (F_{bar} ages 0-3) calculated as the average ages 0 to 3 in 2010 was used and defined as F status quo (F_{sq} = 1.59)

Stock recruitment

Recruitment (class 0) in 2011 has been estimated by first computing the value of the 0-class abundance index of the MEDITS 2011 though slicing of the size distribution in 2011 of MEDITS, and then through linear regression between the 0-class MEDITS abundance index and the stock number of age 0 of the time series 1997-2010. For 2012 and 2013 we used as a recruitment value the average recruitment 2008-2010 because the estimated recruitment in 2011 was too low.

7.5.1.3 Results

A short term projection (Table 7.5.1.3.1), assuming an F_{stq} of 1.59 and a recruitment of 64270 (thousand) individuals in 2011, shows that:

- Fishing at the Fstq (1.59) in the time frame from the year 2011 to 2012 would generate an increase of the catch by 63 %, while the spawning stock biomass (SSB) would also increase slightly (+21% from 2012 to 2013). This confirms the SSB trend observed in the XSA output (EWG 11-12)

- Fishing at $F_{0.1}$ (0.11) for the same time frame (2011-2012) generates a decrease of the catch of 75 % and a spawning stock biomass increase by 278% from 2012 to 2013.

- A 30% reduction of the F_{stq} (F=1.59) generates an increase of catch of 30% and an increase of spawning stock biomass of 75% from the year 2012 to 2013.

In order to reach the target point ($F_{0.1}$), a decrease of Fstq by 90% is needed. Keeping with the present analysis based on Fstq, and the use of $F_{0.1}$ as a target reference point, EWG 11-20 deems that catch for hake in GSA 06 in 2012 should not exceed 836 t, and 2153 t in 2013.

Outlook for 2011-2013

Table 7.5.1.3. Short term forecast in different F scenarios computed for hake in GSA 6.

Basis: F_{stq} = mean (Fbar0-3, 1997-2010); R(2011) = 64270 (thousands); F (2011) = 1.59; SSB(2012) = 2710 t; landings(2011)= 3358 t. Weights in tons.

Rationale	F scenario	F factor	Catch 2012	Catch 2013	SSB 2013	Change SSB 2012-2013 (%)	Change Catch 2010-2012 (%)
zero catch	0.00	0	0	0	11669	330.6	-100
High long-term yield (F0.1)	0.11	0.07	836	2153	10231	277.5	-74.5
Status quo	1.59	1	5354	5712	3272	20.7	63.3
Different scenarios	0.16	0.10	836	2153	10231	277.5	-74.5
	0.32	0.20	1579	3630	8980	231.4	-51.8
	0.48	0.30	2244	4612	7892	191.2	-31.5
	0.64	0.40	2838	5238	6940	156.1	-13.4
	0.80	0.50	3373	5617	6109	125.4	2.9
	0.96	0.60	3851	5818	5385	98.7	17.5
	1.12	0.70	4285	5892	4747	75.2	30.7
	1.28	0.80	4678	5881	4189	54.6	42.7
	1.44	0.90	5032	5815	3700	36.5	53.5
	1.60	1.00	5354	5712	3272	20.7	63.3
	1.76	1.10	5650	5592	2898	6.9	72.4
	1.92	1.20	5921	5457	2564	-5.4	80.6
	2.08	1.30	6169	5321	2277	-16.0	88.2
	2.23	1.40	6394	5185	2021	-25.4	95.1
	2.39	1.50	6606	5052	1796	-33.7	101.5
	2.55	1.6	6797	4923	1594	-41.2	107.4
	2.71	1.7	6976	4807	1418	-47.7	112.8
	2.87	1.8	7141	4700	1264	-53.4	117.8
	3.03	1.9	7296	4598	1128	-58.4	122.6
	3.19	2.0	7439	4505	1005	-62.9	126.9

In the short term predictions done in SGMED 09-03, the forecast catch for 2010 with F_{stq} (1.53) was set to nearly 15000 t when in fact the real value obtained in that year was 3278 t. This large difference between the predicted and the real value is due to the fact that in SGMED 09-03 modelling the recruitment (age 0) in 2010 was estimated with the average of the recruitment of the overall time series (did not account for the declining trend in the recruitment of hake in GSA 06).

7.5.2 Medium term prediction

7.5.2.1 Method and justification

Medium term predictions for a 10 years period were implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) presented at the EWG 11-12. Four scenarios were considered:

1) constant F = $F_{0.1}$
2) 10% reduction in F per year
3) Achievement of F = $F_{0.1}$ by 2015, then fix at F = $F_{0.1}$
4) Linear decrease in F to achieve F = $F_{0.1}$ in 2020

7.5.2.2 Input parameters

The input parameters were the same as the ones used in the short term forecast. The only stochastic simulation was the recruitment, computed from the geometric mean over the whole time series (1997-2010). The rest of the simulation is deterministic: the natural mortality, growth parameters and maturity ogive were assumed constant. We did not consider facts that could affect the medium term projections such as the future changes in mortality (e.g. cannibalism arising from strong year classes), increase in recruitment due to increased stock size, or other parts of the biological environment (e.g. predators) or the physical environment (e.g. sea warming).

7.5.2.3 Results

The medium term consequences of the different harvesting strategies (scenarios) are shown in the figures 7.5.2.3.1 – 7.5.2.3.4. These figures display the 25, 50 and 75 percentiles of the projection of the relevant stock indicators (spawning stock biomass, catches and recruitment) and F from 2011 to 2020. In all scenarios the stock is projected to increase in spawning biomass (particularly under the first and third scenario, even though this estimation includes a great deal of uncertainty which reflects the considerable uncertainty in recent and future year-class strengths, as well as current absolute biomass levels. In all cases catches are also expected to increase, even though in the first and third scenario there is first a short term decrease of the yields in 2010-2013 after which the yield increases).

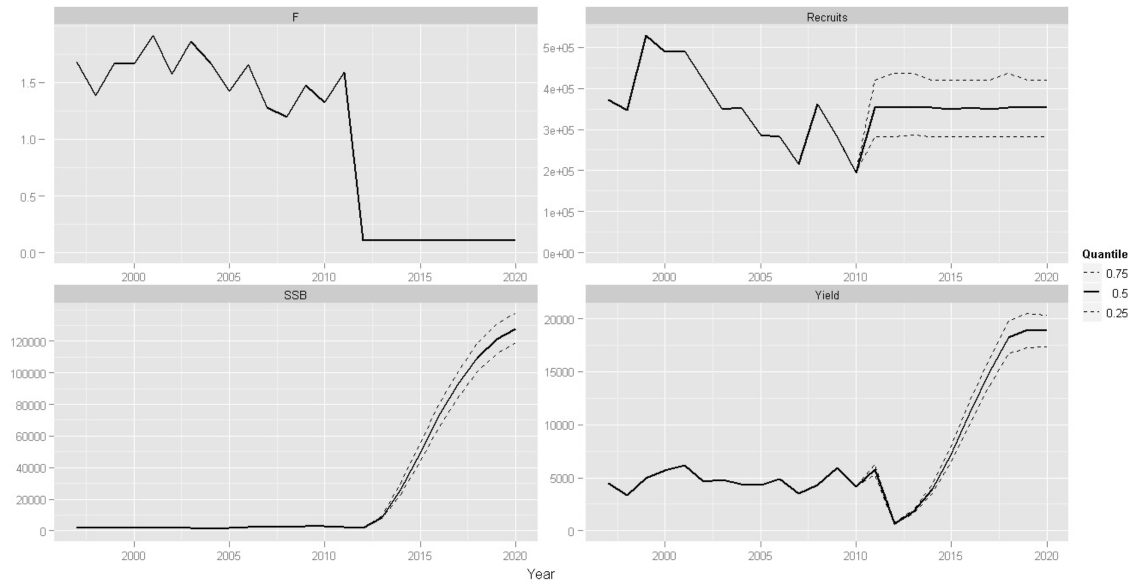


Fig. 7.5.2.3.1. Projection of F, recruits, SSB and yield under scenario 1 (constant F = F 0.1)

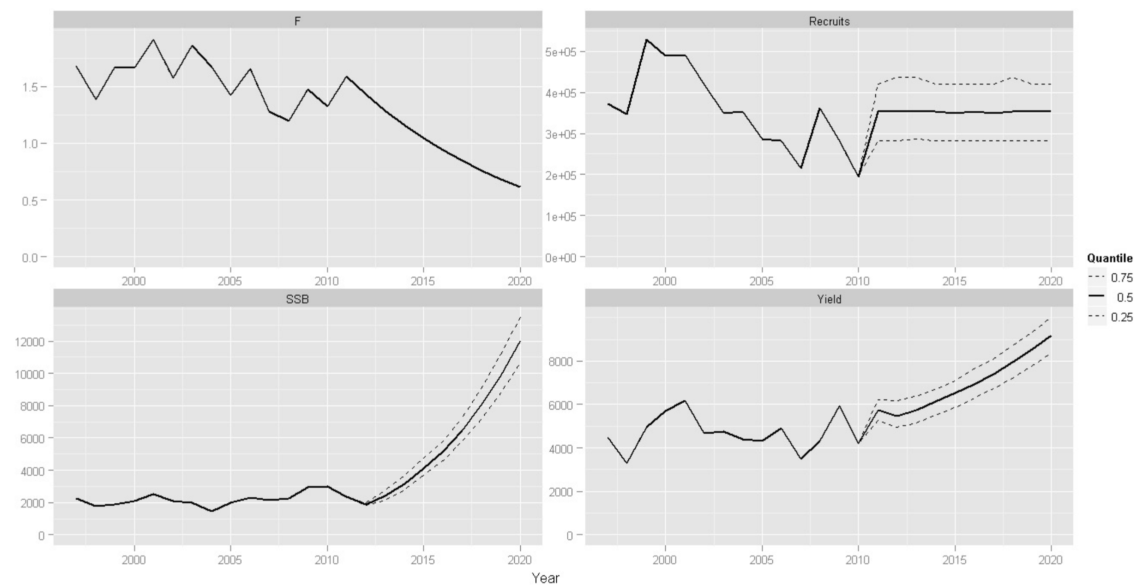


Fig. 7.5.2.3.2. Projection of F, recruits, SSB and yield under scenario 2 (10% reduction in F per year)

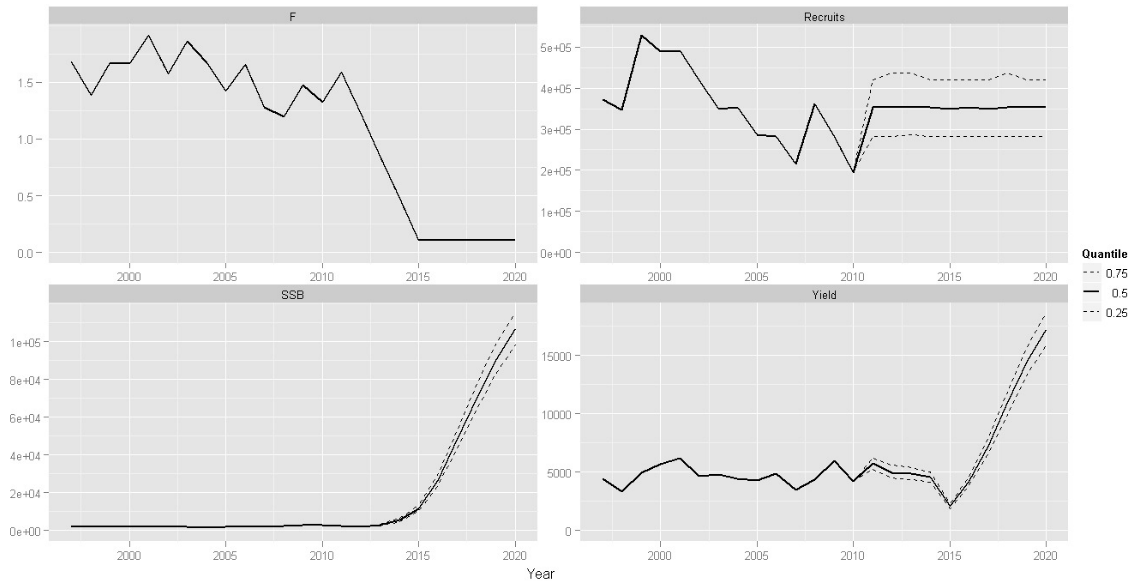


Fig. 7.5.2.3.3. Projection of F, recruits, SSB and yield under scenario 3 (Achievement of F = F0.1 by 2015, then fix at F = F0.1)

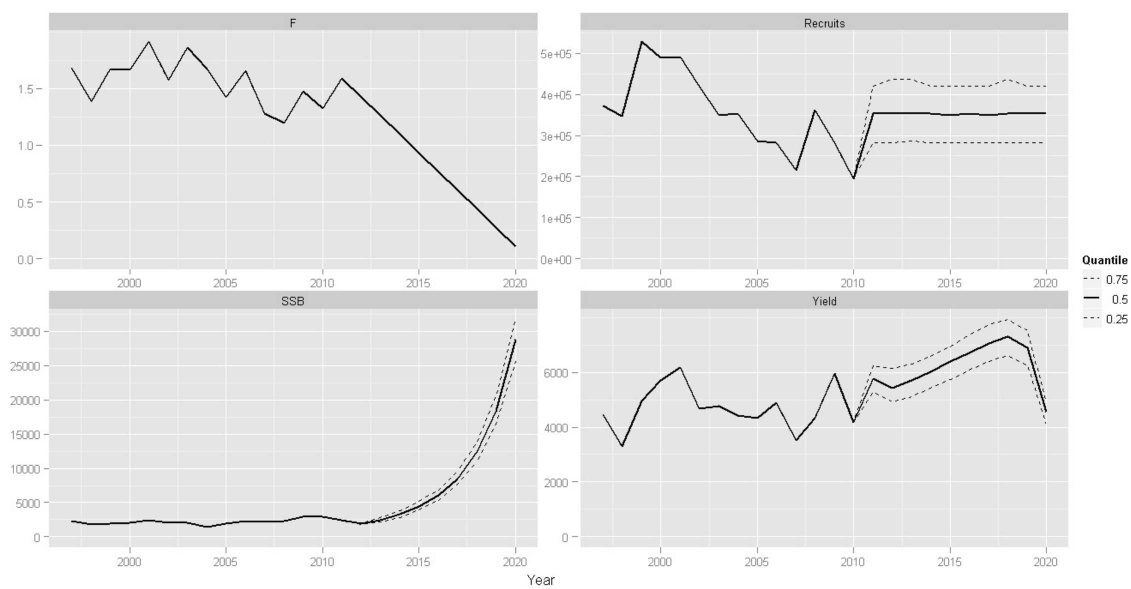


Fig. 7.5.2.3.4. Projection of F, recruits, SSB and yield under scenario 4 (Linear decrease in F to achieve F = F0.1 in 2020)

Data consistency

No age or size distributions were provided for the discards (although discards are neglegible)

7.6 Red mullet (*Mullus barbatus*) in GSA 6

7.6.1 Short term prediction for 2011 -2013

7.6.1.1 Method and justification

A deterministic short term prediction for 2011 to 2013 was performed using the EXCEL workbook provided by JRC IPSC (H.-J. Rätz) which takes into account the catch and landings in numbers and weight by Spanish trawlers and gillnetters, and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) stock assessment performed during EWG 11-12). Data used come from trawlers only because gillnet catch is negligible (2% of the total catch) and because no age or size distributions were provided. Discards were not used because they were very small (about 400 kg in 2010 compared to more than 500 tons landed) and because no age or size distributions were provided for the discards.

7.6.1.2 Input parameters

The following input parameters have been used for the short projection of red mullet in GSA 6. M and weight at age values are the average 2008-2010 values whereas the F values are the averages 2008-2010 of the ages 0-4 rescaled to 2010 values

Maturity and M vectors

PERIOD	Age	0	1	2	3	4	5+
2010	Prop. Matures	0.46	0.76	0.88	0.93	1	1

PERIOD	Age	0	1	2	3	4	5+	Mean 0-4
2010	M	0.99	0.46	0.30	0.24	0.21	0.20	0.44

F vector

F	0	1	2	3	4	5+
2010	0.0144	0.7246	2.232	2.632	1.619	1.619

Weight-at-age in the stock

Mean weight in stock	0	1	2	3	4	5+
kg	0.004	0.026	0.060	0.117	0.195	0.246

Weight-at-age in the catch

Mean weight in catch	0	1	2	3	4	5+

kg	0.004	0.026	0.060	0.117	0.195	0.246

Number at age in the catch

Catch at age in numbers (x 1000)	0	1	2	3	4	5+
2010	21	9574	9006	1366	23	50

Number at age in the stock

Numbers at age in the stock (x 1000)	0	1	2	3	4	5+
2010	46207	25596	11305	1696	33	67

Different scenarios of constant harvest strategy with reduction of the mean F (F_{bar} ages 0-4) calculated as the average ages 0 to 4 in 2010 was used and defined as F status quo (F_{sq} = 1.44)

Stock recruitment

Recruitment (class 0) in 2011 has been estimated from the average 2008-2010 stock numbers at age 0 because the relationship between stock numbers and MEDITS survey indices (age 0) is too low (R^2=0.0017) and therefore this prevents estimating the recruitment in 2011 from the MEDITS 2010 data. The low correlation is explained by the fact that the recruitment of *M. barbatus* occurs in autumn while the MEDITS survey is carried out in spring.

7.6.1.3 Results

A short term projection (Table 7.6.1.3.1), assuming an Fstq of 1.44 and a recruitment of 72292 (thousand) individuals in 2011, shows that:

- Fishing at the Fstq (1.44) in the time frame from the year 2011 to 2012 would generate a decrease of the catch by 25 %, coinciding with the observed trend in landings (EWG 11-12), while the spawning stock biomass would increase slightly (+6% from 2012 to 2013).

- Fishing at $F_{0.1}$ (0.38) for the same time frame (2011-2012) would generate a decrease of the catch of 69 % and a spawning stock biomass increase by 58% from 2012 to 2013.

- A 30% reduction of the Fstq (F=1.44) generates a decrease of catch of 40% and an increase of spawning stock biomass of 24% from the year 2012 to 2013.

In order to reach the target point (F0.1), a decrease of Fstq by 74% is needed. Keeping with the present analysis based on Fstq, and the use of F0.1 as a target reference point, EWG 11-20 deems that catch for red mullet in GSA 6 in 2012 should not exceed 302 t, and 850 t in 2013.

Outlook for 2011-2013

Table 7.6.1.3.1– Short term forecast in different F scenarios computed for red mullet in GSA 6.

Basis: F_{stq} = mean (Fbar0-4, 2002-2010); R(2011) = 72292 (thousands); F (2011) = 1.44; SSB (2012) = 1274 t; landings (2011)= 591 t. Weights in tons.

Rationale	F scenario	F factor	Catch 2012	Catch 2013	SSB 2013	Change SSB 2012-2013 (%)	Change Catch 2010-2012 (%)
zero catch	0.00	0	0	0	2454	95.4	-100
High long-term yield (F0.1)	0.38	0.26	302	850	2014	58	-69
Status quo	1.44	1	725	956	1337	6.4	-25.4
Different scenarios	0.00	0.00	0	0	2454	95.4	-100.0
	0.14	0.10	115	370	2272	80.9	-88.2
	0.29	0.20	216	619	2113	68.2	-77.8
	0.43	0.30	307	778	1972	57.0	-68.4
	0.58	0.40	387	879	1849	47.2	-60.2
	0.72	0.50	458	938	1739	38.5	-52.9
	0.87	0.60	523	969	1640	30.6	-46.2
	1.01	0.70	580	983	1553	23.6	-40.3
	1.16	0.80	632	983	1474	17.4	-35.0
	1.30	0.90	681	972	1401	11.5	-29.9
	1.44	1.00	725	956	1337	6.4	-25.4
	1.59	1.10	767	939	1277	1.7	-21.1
	1.73	1.20	802	918	1225	-2.5	-17.5
	1.88	1.30	837	897	1174	-6.5	-13.9
	2.02	1.40	868	873	1129	-10.1	-10.7
	2.17	1.50	899	853	1087	-13.5	-7.5
	2.31	1.60	925	832	1048	-16.6	-4.8
	2.46	1.70	950	811	1013	-19.3	-2.3
	2.60	1.80	972	792	981	-21.9	0.0
	2.74	1.90	996	773	948	-24.5	2.5
	2.89	2.00	1017	756	921	-26.7	4.6

There were not short term predictions done in SGMED 09-03 to be compared to the actual analyses for that stock.

7.6.2 Medium term prediction

7.6.2.1 Method and justification

Medium term predictions for a 10 years period were implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) presented at the EWG 11-12. Four scenarios were considered:

1) constant F = $F_{0.1}$
2) 10% reduction in F per year
3) Achievement of F = $F_{0.1}$ by 2015, then fix at F = $F_{0.1}$
4) Linear decrease in F to achieve F = $F_{0.1}$ in 2020

7.6.2.2 Input parameters

The input parameters were the same as the ones used in the short term forecast. The only stochastic simulation was the recruitment, computed from the geometric mean over the whole time series (2002-2010). The rest of the simulation is deterministic: the natural mortality, growth parameters and maturity ogive were assumed constant. We did not consider facts that could affect the medium term projections such as the future changes in mortality (e.g. cannibalism arising from strong year classes), increase in recruitment due to increased stock size, or other parts of the biological environment (e.g. predators) or the physical environment (e.g. sea warming: Levi et al. 2003 found that higher sea surface temperatures result in higher levels of recruitment of red mullet in the Srait of Sicily).

7.6.2.3 Results

The medium term consequences of the different harvesting strategies (scenarios) are shown in the figures 7.6.2.3.1 to 7.6.2.3.4. These figures display the 25, 50 and 75 percentiles of the projection of the relevant stock indicators (spawning stock biomass, catches and recruitment) and F from 2011 to 2020. In all scenarios (particularly 7.6.2.3.1, 7.6.2.3.3 and 7.6.2.3.4) the stock is projected to increase in spawning biomass, although this estimation includes a great deal of uncertainty which reflects the considerable uncertainty in recent and future year-class strengths, as well as current absolute biomass levels. In all cases catches are also expected to increase even though in the 4th scenario there seems to be a threshold in the long-term (by 2020), which remains however very uncertain.

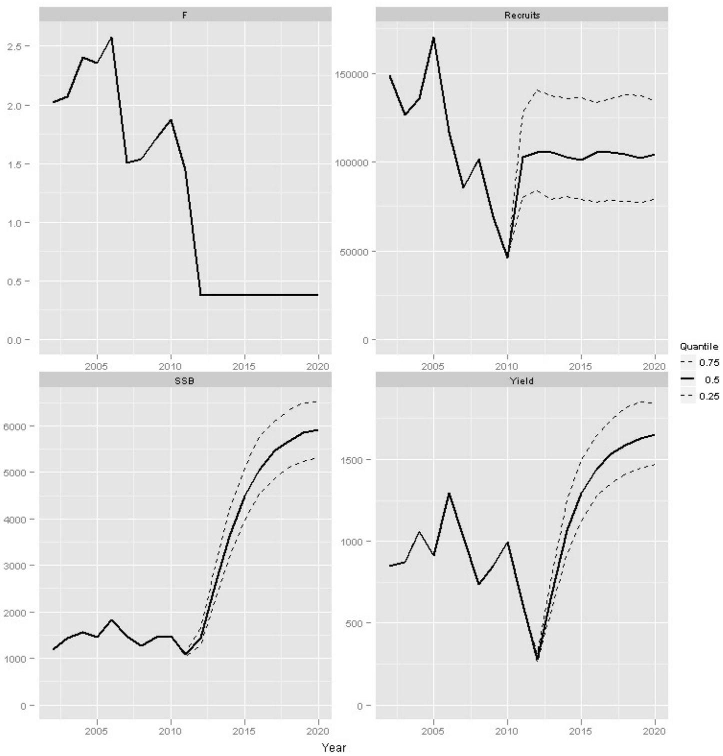


Fig. 7.6.2.3.1. Projection of F, recruits, SSB and yield under scenario 1 (constant F = $F_{0.1}$)

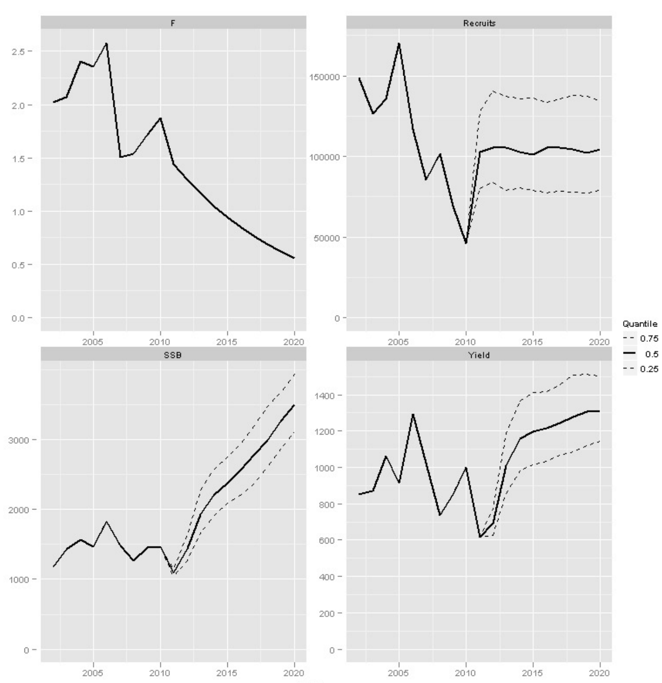


Fig. 7.6.2.3.2. Projection of F, recruits, SSB and yield under scenario 2 (10% reduction in F per year)

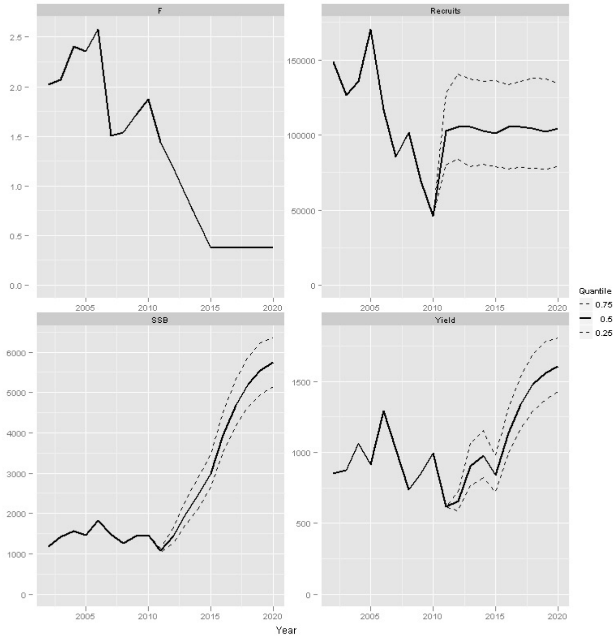


Fig. 7.6.2.3.3. Projection of F, recruits, SSB and yield under scenario 3 (Achievement of F = $F_{0.1}$ by 2015, then fix at F = F0.1)

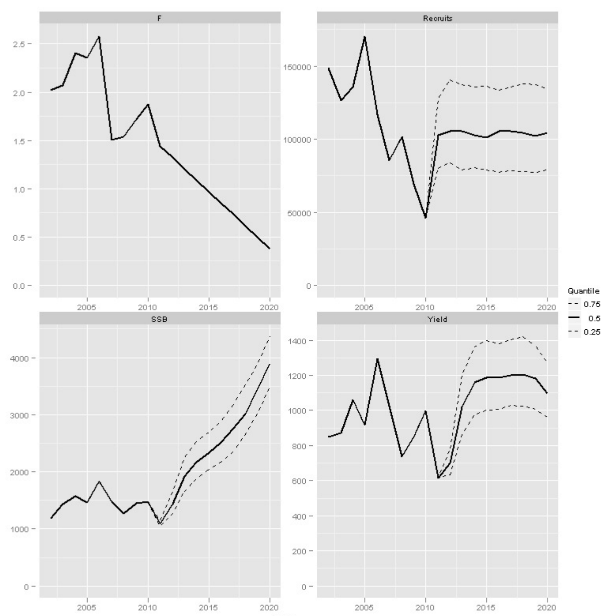


Fig. 7.6.2.3.4. Projection of F, recruits, SSB and yield under scenario 4 (Linear decrease in F to achieve F = F0.1 in 2020)

Data consistency

No age or size distributions were provided for gillnetters as well as for the discards (although the disdards are negligible)

7.7 Pink shrimp (*Parapenaeus longirostris*) in GSA 6

7.7.1 Short term prediction for 2011 - 2013

7.7.1.1 Method and justification

A deterministic short term prediction for 2011 to 2013 was performed using the EXCEL workbook provided by JRC IPSC (H.-J. Rätz) which takes into account the catch and landings in numbers and weight by Spanish trawlers (the only fleet exploiting this species), and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) stock assessment performed during STECF EWG 11-12. Discards were not used because they were very small (816 kg in 2010 compared to the 141 tons landed), and because no age or size distributions were provided for the discards.

7.7.1.2 Input parameters

The following input parameters have been used for the short projection of pink shrimp in GSA 6. M and weight at age values are the average 2008-2010 values whereas the F values are the averages 2008-2010 rescaled to 2010 values to take into account the trend in F.

Maturity and M vectors

PERIOD	Age	0	1	2	3	4	5	6+
2010	Prop. Matures	0	0.13	0.50	0.79	0.90	0.97	1

PERIOD	Age	0	1	2	3	4	5	6+	Mean 0-4
2010	M	1.25	0.82	0.39	0.28	0.24	0.22	0.21	0.49

F vector

F	0	1	2	3	4	5	6+
2010	0.001	0.13	0.93	1.34	1.63	0.81	0.81

Weight-at-age in the stock

Mean weight in stock	0	1	2	3	4	5	6+
kg	0.001	0.007	0.011	0.018	0.025	0.029	0.033

Weight-at-age in the catch

Mean weight in catch	0	1	2	3	4	5	6+
kg	0.001	0.007	0.011	0.018	0.025	0.029	0.033

Number at age in the catch

Catch at age in numbers (x 1000)	0	1	2	3	4	5	6+
2010	0	2454	7281	2487	194	8	1

Number at age in the stock

Numbers at age in the stock (x 1000)	0	1	2	3	4	5	6+
2010	92021	29178	11930	3232	243	14	1

Different scenarios of constant harvest strategy with reduction of the mean F (F_{bar} ages 0-5) calculated as the average ages 0 to 5 in 2010 was used and defined as F status quo (F_{sq} = 0.81)

Stock recruitment

Recruitment (class 0) in 2011 has been estimated from the average 2008-2010 stock numbers at age 0 because the relationship between stock numbers and MEDITS survey indices (age 0) is low (R^2=0.25) and therefore this prevents estimating the recruitment in 2011 from the MEDITS 2010 data. This low correlation can be due to the low representativeness of the 0-class in the MEDITS and trawl catch (due to gear efficiency, market strategies, etc)

7.7.1.3 Results

A short term projection (Table 7.7.1.3.1), assuming an F_{stq} of 0.81 and a recruitment of 101603 (thousand) individuals in 2011, shows that:

- Fishing at the F_{stq} (0.81) in the time frame from the year 2011 to 2012 would generate an increase of the catch by 50 % and an increase of the spawning stock biomass (SSB) of 34% from 2012 to 2013. This confirms the positive trend in both SSB and landings observed in the XSA output (EWG 11-12)

- Fishing at $F_{0.1}$ (0.264) for the same time frame (2011-2012) generates a decrease of the catch of 38 % and a spawning stock biomass increase by 77% from 2012 to 2013.

- A 30% reduction of the F_{stq} (F=0.81) generates a slight increase of catch by 15% and an increase of spawning stock biomass by 50% from the year 2012 to 2013.

In order to reach the target point (F0.1), a decrease of F_{stq} by 90 % is needed. Keeping with the present analysis based on F_{stq}, and the use of $F_{0.1}$ as a target reference point, EWG 11-20 deems that catch for pink shrimp in GSA 6 in 2012 should not exceed 87 t, and 179 t in 2013.

Outlook for 2011-2013

Table 7.7.1.3.1– Short term forecast in different F scenarios computed for pink shrimp in GSA 6

Basis: F_{stq} = mean(Fbar0-5, 2001-2010); R(2011) = 101603 (thousands); F (2011) = 0.81; SSB(2012) = 250 t; landings(2011)= 120 t. Weights in tons.

Rationale	F scenario	F factor	Catch 2012	Catch 2013	SSB 2013	Change SSB 2012-2013 (%)	Change Catch 2010-2012 (%)
zero catch	0	0	0	0	524	190.6	-100
High long-term yield (F0.1)	0.264	0.34	87	179	443	77	-38
Status quo	0.81	1	212	315	334	34	50
Different scenarios	0.08	0.1	29	69	497	98.8	-79.4
	0.16	0.2	56	124	472	88.8	-60.3
	0.24	0.3	80	169	449	79.6	-43.3
	0.32	0.4	103	204	428	71.2	-27.0
	0.40	0.5	125	233	407	62.8	-11.3
	0.48	0.6	144	256	390	56.0	2.1
	0.57	0.7	163	276	374	49.6	15.6
	0.65	0.8	180	292	360	44.0	27.7
	0.73	0.9	197	305	347	38.8	39.7
	0.81	1.0	212	315	334	33.6	50.4
	0.89	1.1	227	323	321	28.4	61.0
	0.97	1.2	240	328	311	24.4	70.2
	1.05	1.3	252	334	301	20.4	78.7
	1.13	1.4	263	336	292	16.8	86.5
	1.21	1.5	274	340	284	13.6	94.3
	1.29	1.6	285	343	276	10.4	102.1
	1.37	1.7	295	344	269	7.6	109.2
	1.45	1.8	306	344	261	4.4	117.0
	1.54	1.9	315	346	256	2.4	123.4
	1.62	2.0	323	345	249	-0.4	129.1

In the short term predictions done in SGMED 09-03, the forecast catch for 2010 with F_{stq} (0.43) was set to 54 t when in fact the real value obtained in that year was 141 t. This difference between the predicted and the real value can be due to the fact that landings data for that species improved after 2010 when experts could collect better data which is displayed in EWG 11-05. As stated in EWG 11-12, there were large differences between landings data submitted in 2011 versus the landings submitted in 2010 for the period 2002-2009.

7.7.2 Medium term prediction

7.7.2.1 Method and justification

Medium term predictions for a 10 years period were implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) presented at the EWG 11-12. Four scenarios were considered:

1) constant $F = F_{0.1}$

2) 10% reduction in F per year

3) Achievement of $F = F_{0.1}$ by 2015, then fix at $F = F_{0.1}$

4) Linear decrease in F to achieve $F = F_{0.1}$ in 2020

7.7.2.2 Input parameters

The input parameters were the same as the ones used in the short term forecast. The only stochastic simulation was the recruitment, computed from the geometric mean over the whole time series (2001-2010). The rest of the simulation is deterministic: the natural mortality, growth parameters and maturity ogive were assumed constant. We did not consider facts that could affect the medium term projections such as the future changes in mortality (e.g. cannibalism arising from strong year classes), increase in recruitment due to increased stock size, or other parts of the biological environment (e.g. predators) or the physical environment (e.g. sea warming).

7.7.2.3 Results

The medium term consequences of the different harvesting strategies (scenarios) are shown in the figures 7.7.2.3.1 to 7.7.2.3.4. These figures display the 25, 50 and 75 percentiles of the projection of the relevant stock indicators (spawning stock biomass, catches and recruitment) and F from 2011 to 2020. In all scenarios (particularly 7.7.2.3.1, 7.7.2.3.3 and 7.7.2.3.4) the stock is projected to increase in spawning biomass, although this estimation includes a great deal of uncertainty which reflects the considerable uncertainty in recent and future year-class strengths, as well as current absolute biomass levels. Under scenario 1 the catches are expected to increase slightly. Under scenarios 2 and 3 the catches are expected to fluctuate at a similar level to the yield obtained in 2010 whereas under scenario 3 the catches are expected to decrease slightly.

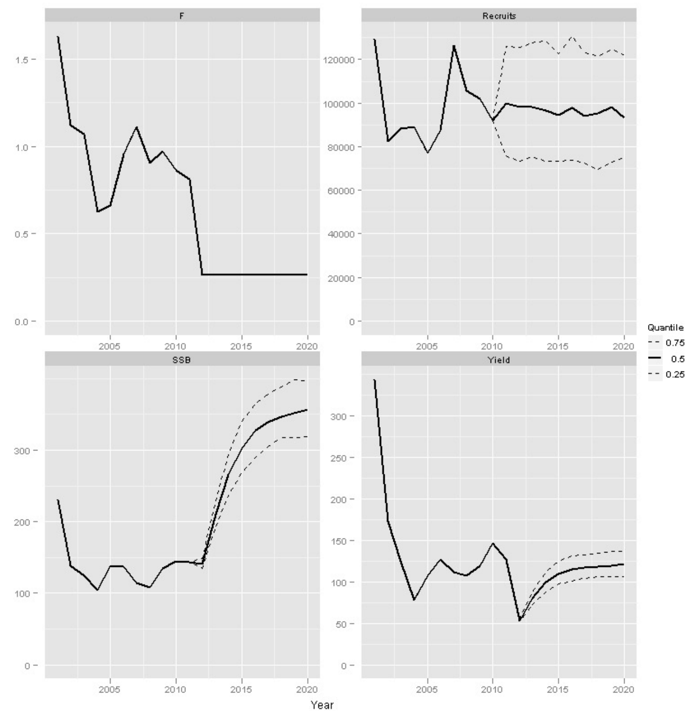


Fig. 7.7.2.3.1. Projection of F, recruits, SSB and yield under scenario 1 (constant F = $F_{0.1}$).

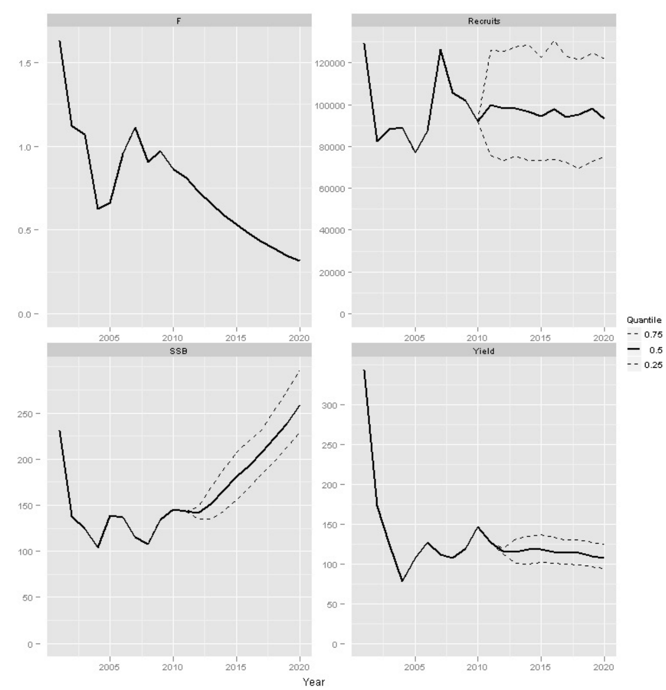


Fig. 7.7.2.3.2. Projection of F, recruits, SSB and yield under scenario 2 (10% reduction in F per year).

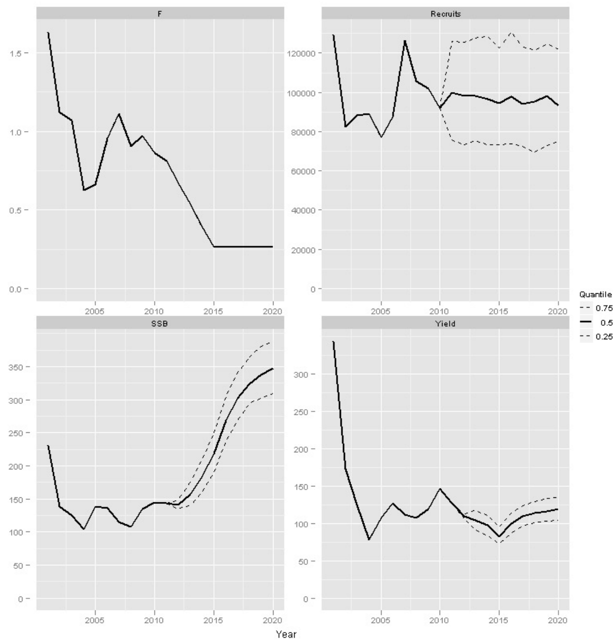


Fig. 7.7.2.3.3. Projection of F, recruits, SSB and yield under scenario 3 (Achievement of F = $F_{0.1}$BY 2015, then fix at F = $F_{0.1}$).

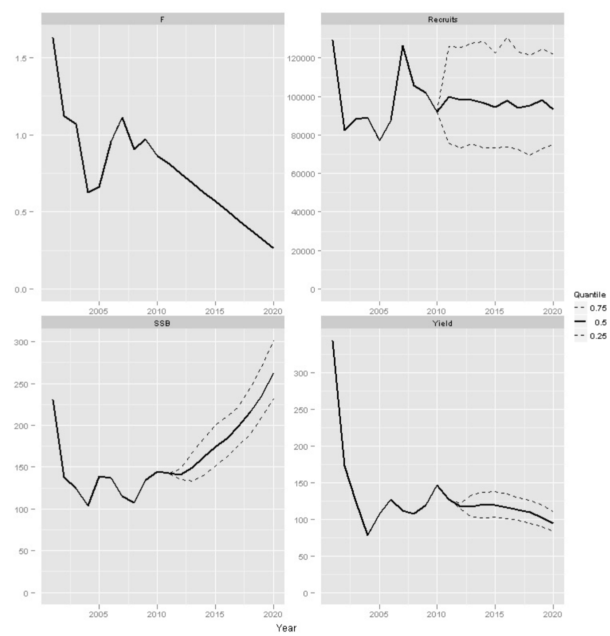


Fig. 7.7.2.3.4. Projection of F, recruits, SSB and yield under scenario 4 (Linear decrease in F to achieve F = $F_{0.1}$ in 2020).

Data consistency

No age or size distributions were provided for the discards (although the discards were neglegible)

7.8 European hake (*Merluccius merluccius*) in GSA 7

7.8.1 Short term prediction 2011-2012

7.8.1.1 Method and justification

Short term predictions were implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) reviewed at the current STECF EWG 11-20.

7.8.1.2 Input parameters

The following data have been used to drive the input data for the short term projection of the hake stock in GSA 7:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4	5	6	7	8+
1998-2010	Prop. Matures	0	0.11	0.63	0.91	0.98	0.99	1	1	1

PERIOD	Age	0	1	2	3	4	5	6	7	8+
1998-2010	M	0.88	0.43	0.33	0.25	0.22	0.20	0.19	0.18	0.17

F vector

F	0	1	2	3	4	5	6	7	8+
2010	0.20	0.96	1.30	1.54	1.35	0.59	0.16	0.00	0.00

Several scenarios with different harvest strategy were run, with F_{stq} (F_{bar} ages 0-3, mean of last 3 years)

Weight-at-age in the stock

Mean weight in stock (kg)	0	1	2	3	4	5	6	7	8+
1998-2010	0.03	0.12	0.39	0.86	1.37	1.98	2.41	4.35	4.86

Weight-at-age in the catch

Mean weight in catch (kg)	0	1	2	3	4	5	6	7	8+
1998-2010	0.03	0.12	0.39	0.86	1.37	1.98	2.41	4.35	4.86

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2	3	4	5	6	7	8+
2010	*6884*	*9825*	*2145*	*186*	*15*	1	0	0	0

Number at age in the stock

Stock at age in numbers (thousands)	0	1	2	3	4	5	6	7	8+
2011	42106*	12453	2748	413	25	2	1	0	13

Recruitment

Recruitment (class 0) has been estimated with the regression between MEDITS indices (n/h) and XSA results (numbers of age 0): estimated value was 42106 (thousands) individuals described in the Table 7.8.1.2.1 and Figure 7.8.1.2.1 below.

Table 7.8.1.2.1 Projection of Recruitment (Age 0+) based on the relationship between the MEDITS survey index and the results of XSA (Age 0+)

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
MEDITS abundance index (n/h)	46392	13757	40130	34419	61553	4944	30999	13668	17858	17108	76973	30477	22335	10230
XSA - Age 0 (n*1000)	71317	44995	52588	76470	75675	34359	35711	31667	31744	71219	51656	45471	40817	**42106**

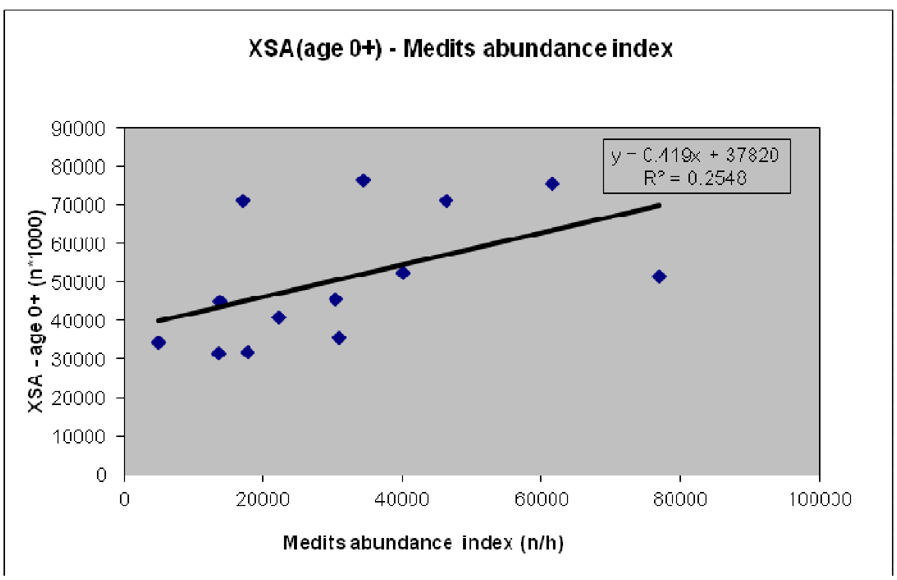


Fig. 7.8.1.2.1. Projection of recruitment (Age 0+) based on the relationship between the MEDITS index and the results of XSA (Age 0+).

7.8.1.3 Results

Short-term implications

A short term projection (Table 7.8.1.3.1), assuming an F_{stq} of 1.43 in 2010 (mean 0-3 ages) and a recruitment of 42106 (thousand) individuals, shows that:

- Fishing at the F_{stq} (1.43) generates a decrease of the catch of 12 % from 2010 to 2012 along with a decrease of the spawning stock biomass of 5 % from 2011 to 2012.

- Fishing at $F_{0.1}$ (0.24) generates a decrease of the catch of 76 % from 2010 to 2012 and a spawning stock biomass increase by 160 % from 2012 to 2013.

- EWG 11-20 recommends that catch in 2012 should not exceed 572 tons, corresponding to $F_{0.1} = 0.24$.

Outlook until 2011, all fleets combined (Spanish and French bottom trawl, Spanish longline, French gillnet).

Table 7.8.1.3.1 Short term forecast in different F scenarios computed for hake in GSA 7. (All fleets combined: Spanish and French bottom trawl, Spanish longline, French gillnet).

Basis: F (2010) = mean (F_{bar} 0-3 2008-2010); R (2010) = regression MEDITS indices 2010 = 42106 (thousands); F (2010) = 1.43; SSB (2012) = 1054 t; Catch (2011)= 2360 t. Weights in tons.

Rationale	Ffactor	fbar	Catch 2012	Catch 2013	SSB 2013	Change SSB 2012-2013 (%)	Change Catch 2010-2012 (%)
zero catch	0,00	0,00	0	0	3957	229	-100
High long-term yield (F0,1)	0,20	0,24	572	1300	3088	160	-76
Status quo	1,00	1,43	2075	2036	995	-5	-12
Different scenarios	0,10	0,14	360	891	3408	185	-85
	0,20	0,29	670	1460	2941	149	-72
	0,30	0,43	939	1811	2544	117	-60
	0,40	0,57	1173	2015	2206	91	-50
	0,50	0,71	1376	2120	1918	68	-42
	0,60	0,86	1554	2161	1672	49	-34
	0,70	1,00	1710	2159	1462	32	-28
	0,80	1,14	1847	2131	1282	18	-22
	0,90	1,28	1968	2088	1128	6	-17
	1,00	1,43	2075	2036	995	-5	-12
	1,10	1,57	2170	1980	882	-14	-8
	1,20	1,71	2255	1923	784	-21	-4
	1,30	1,86	2332	1867	700	-28	-1
	1,40	2,00	2400	1814	627	-34	2
	1,50	2,14	2462	1764	564	-39	4
	1,60	2,28	2518	1717	510	-43	7
	1,70	2,43	2570	1673	463	-47	9
	1,80	2,57	2616	1632	422	-50	11
	1,90	2,71	2659	1595	386	-53	13
	2,00	2,86	2699	1560	355	-55	14

Data consistency

No particular issue was identified with data quality and data consistency.

7.8.2 *Medium term prediction*

7.8.2.1 Method and justification

Medium term predictions for a 10 years period were implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) presented at the EWG 11-20. Four predictions were conducted:

1) constant $F = F_{0.1}$
2) 10% reduction in F per annum
3) Hit $F = F_{0.1}$ by 2015, then fix at $F = F_{0.1}$
4) Linear decrease in F to hit $F = F_{0.1}$ in 2020

7.8.2.2 Input parameters

The input parameters were exactly the same as the ones used in the short term forecast.

The recruitment is a geometric mean of the last 3 years.

7.8.2.3 Method and justification

The medium term consequences of the different harvesting strategies (scenarios) are shown in the figures 7.8.2.3.1 to 7.8.2.3.4. These figures display the 25, 50 and 75 percentiles of the projection of the relevant stock indicators (spawning stock biomass, catches and recruitment) and F from 2011 to 2020.

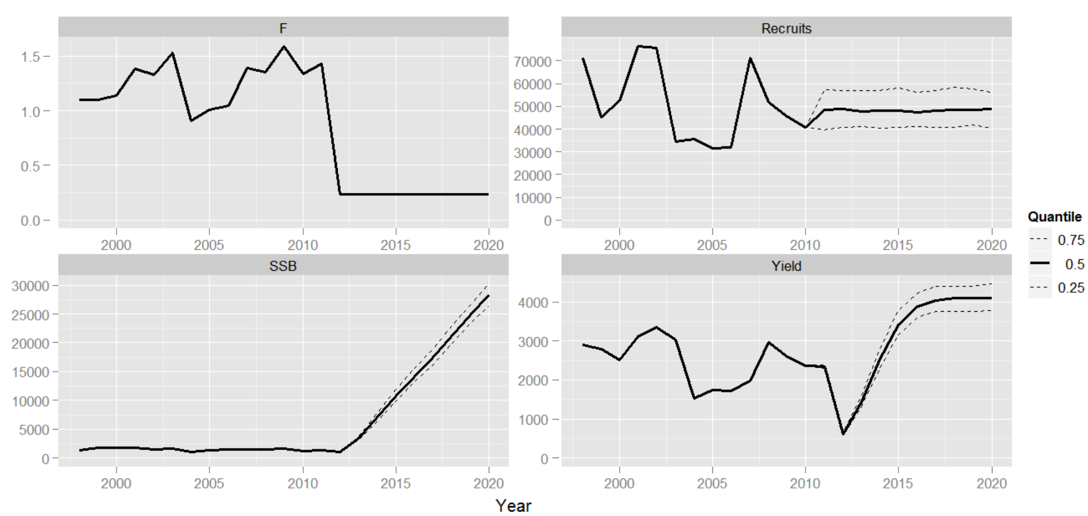


Fig. 7.8.2.3.1. Projection of F, recruits, SSB and yield under scenario 1 (constant $F = F_{0.1}$).

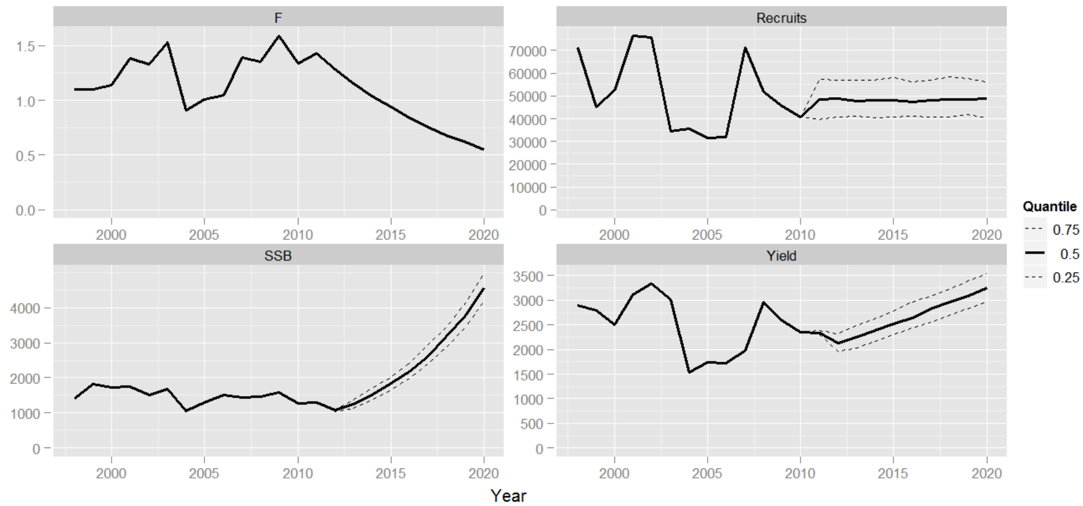


Fig. 7.8.2.3.2. Projection of F, recruits, SSB and yield under scenario 2.

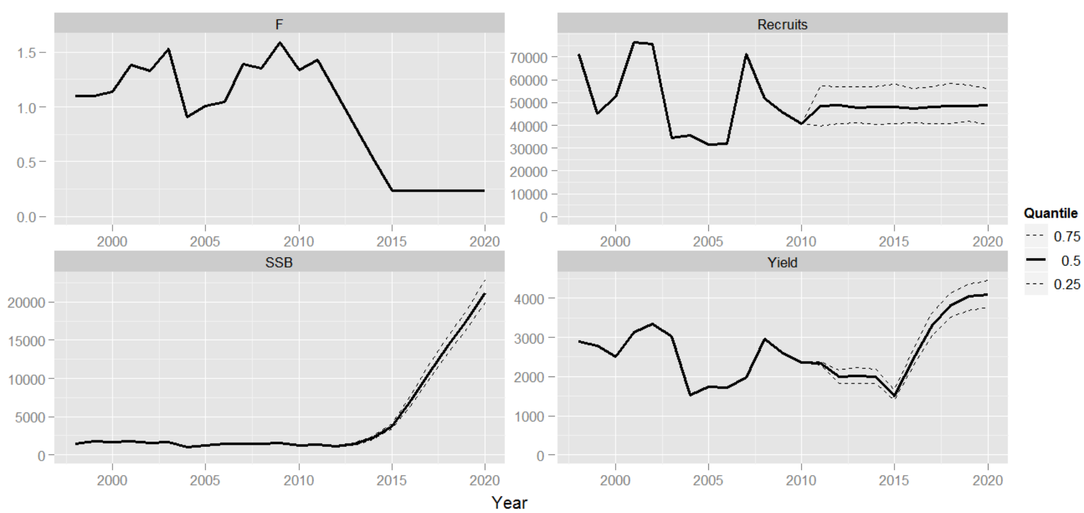


Fig. 7.8.2.3.3. Projection of F, recruits, SSB and yield under scenario 3.

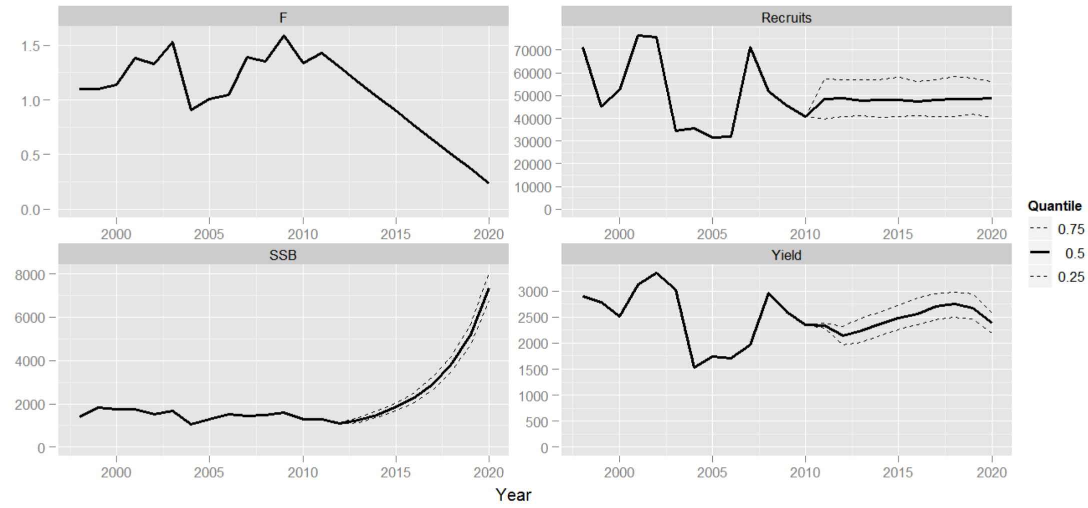


Fig. 7.8.2.3.4. Projection of F, recruits, SSB and yield under scenario 4.

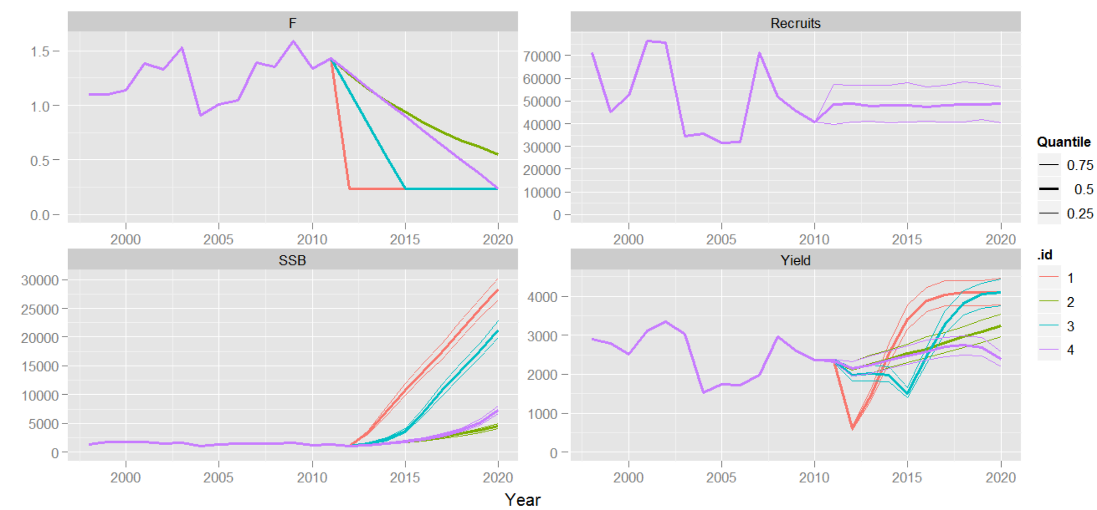


Fig. 7.8.2.3.5. Projection of F, recruits, SSB and yield under scenario 1 to 4.

The decrease in fishing mortality to the $F_{0.1}$ from 2011 to 2012 (first prediction) determines a considerable increase of the SSB (multiplied by 15 in comparison to the SSB of 2011). The stock recovery was achieved along a decrease in catches until 2012, and then with a rapid increase of the catches. One of the explanation could be the very strong year classes 2007 and 2008 (Age 0 and 1) becoming fully mature at age 3, which can explain the very high values of the SSB when F is reduced in one year to the $F_{0.1}$ and the rapid increase of the catches in the medium term. The third prediction (reach $F_{0.1}$ by 2015, then fix at $F = F_{0.1}$) showed a less positive impact of the reduction of the F_{stq} on the SSB (multiplied 10 times) and the catches increase after 2015 to the same level of catches than in scenario 1. The second prediction (10% reduction in F per annum) showed the less positive impacts which nevertheless is an increase of SSB (multiplied by 2). The 4th scenario (Linear decrease in

F to hit F = $F_{0.1}$ in 2020) showed some slight increase of the SSB (multiplied by 2) and some slight increase of the catches until 2018 afterwards catches decreased. It is important to notice that this stock is highly dependent of recruitment since 90% of catches are ages 0 and 1.

STECF EWG 11-20 recognizes that the stock of hake in GSA 7 has a high recovery potential in the short and medium term (next 10 years) due to the projected continuous high recruitment and reduction of the fishing mortality to achieve a sustainable level in 2011, 2015 and 2020. STECF EWG 11-20 recommends that appropriate management measures being implemented to materialize the potential recovery given by the presence of large year classes in the stock. EWG 11-20 notes also that the hake is mainly caught in a mixed fisheries which imply a management plan being designed and implemented which takes into account both multi-species landings and fishing efforts constraints.

7.9 Red mullet (*Mullus barbatus*) in GSA 7

7.9.1 Short term prediction 2009-2011

7.9.1.1 Method and justification

Short term predictions were implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) presented at the EWG -11-20 (Madrid).

7.9.1.2 Input parameters

The following data have been used to derive the input data for the short term projection of the red mullet stock in GSA 7:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4	5+
2004-2010	Prop. Matures	0	1	1	1	1	1

PERIOD	Age	0	1	2	3	4	5+
2004-2010	M	1.3	0.79	0.62	0.54	0.54	0.54

F vector

F	0	1	2	3	4	5+
2004-2010	0.27	1.73	1.59	0.41	0.5	0.5

Weight-at-age in the stock

Mean weight in stock (kg)	0	1	2	3	4	5+
2008-2010	0.017	0.054	0.121	0.186	0.220	0.264

Weight-at-age in the catch

Mean weight in catch (kg)	0	1	2	3	4	5+
2008-2010	0.017	0.054	0.121	0.186	0.220	0.264

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2	3	4	5+
2010	6112	2943	203	14	3	0.2

Number at age in the stock

Stock at age in numbers (thousands)	0	1	2	3	4	5+
2011	26039*	5060	332	138	5	0

Different scenarios of constant harvest strategy with F_{bar} calculated as the average of ages 0 to 3 (F_{bar} ages 0-3) and F status quo ($F_{stq} = 0.93$) were performed.

Stock recruitment

Recruitment (class 0) has been estimated from the population results from the mean of the last three years 2008-2010 estimated with FLR.

7.9.1.3 Results

A short term projection (Table 7.9.1.3.1), assuming an F_{stq} of 0.93 in 2010 and a recruitment of 26039 (thousands) individuals, shows that:

- Fishing at the F_{stq} (0.93) generates an increase of the catch of 9% from 2010 to 2012 along with a decrease of the spawning stock biomass of 5% from 2012 to 2013.

- Fishing at $F_{0.1}$ (0.51) generates a decrease of the catch of 26% from 2010 to 2012 and an increase of the spawning stock biomass of 31% from 2012 to 2013.

Outlook until 2011

Table 7.9.1.3.1. Short term forecast in different F scenarios computed for red mullet in GSA 7.

Basis: F(2010) = mean(F_{bar}0-3 2008-2010); R(2010) = mean of the recruitment of the last 3years; R = 26039 (thousands); F (2010) = 0.93; SSB(2011) = 370 t, Catch (2010)= 270 t. Weights in tons.

Rationale	F factor	F bar	Catch 2012	Catch 2013	SSB 2013	Change SSB 2012-2013 (%)	Change Catch 2010-2012 (%)
zero catch	0.0	0.00	0	0	770	113	-100
High long-term yield ($F_{0.1}$)	0.60	0.51	199	235	503	31	-26
Status quo	1.0	0.93	295	282	384	-5	9
Different scenarios	0.1	0.09	46	74	706	93	-83
	0.2	0.19	88	129	649	76	-68
	0.3	0.28	124	171	600	61	-54
	0.4	0.37	157	203	557	47	-42
	0.5	0.46	186	226	519	36	-31
	0.6	0.56	213	244	485	25	-21
	0.7	0.65	236	258	455	16	-12
	0.8	0.74	258	268	429	8	-4
	0.9	0.83	278	276	405	1	3
	1.0	0.93	295	282	384	-5	9
	1.1	1.02	312	286	365	-11	15
	1.2	1.11	326	290	348	-17	21
	1.3	1.21	340	292	333	-21	26
	1.4	1.30	353	294	319	-26	31
	1.5	1.39	365	295	306	-30	35
	1.6	1.48	376	296	294	-33	39
	1.7	1.58	386	297	283	-37	43
	1.8	1.67	396	298	273	-40	47
	1.9	1.76	405	298	263	-43	50
	2.0	1.85	413	299	254	-45	53

Data consistency

No particular issue was identified with data quality and data consistency.

7.9.2 Medium term prediction

7.9.2.1 Method and justification

Medium term predictions for a 10 years period were implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) presented at the EWG 11-20. Four predictions were conducted:

1) constant $F = F_{0.1}$

2) 10% reduction in F per annum

3) Hit $F = F_{0.1}$ by 2015, then fix at $F = F_{0.1}$

4) Linear decrease in F to hit $F = F_{0.1}$ in 2020

7.9.2.2 Input parameters

The input parameters were exactly the same as the ones used in the short term forecast. The recruitment is a geometric mean of the last 3 years.

7.9.2.3 Results

The medium term consequences of the different harvesting strategies (scenarios) are shown in the figures 7.9.2.3.1 to 7.9.2.3.4. These figures display the 25, 50 and 75 percentiles of the projection of the relevant stock indicators (spawning stock biomass, catches and recruitment) and F from 2011 to 2020.

In Figure 7.9.2.3.1 are represented the results of the Medium term forecast (Scenario 1) estimated for red mullet in GSA 7 (scenario, Recruits, Catch and SSB).

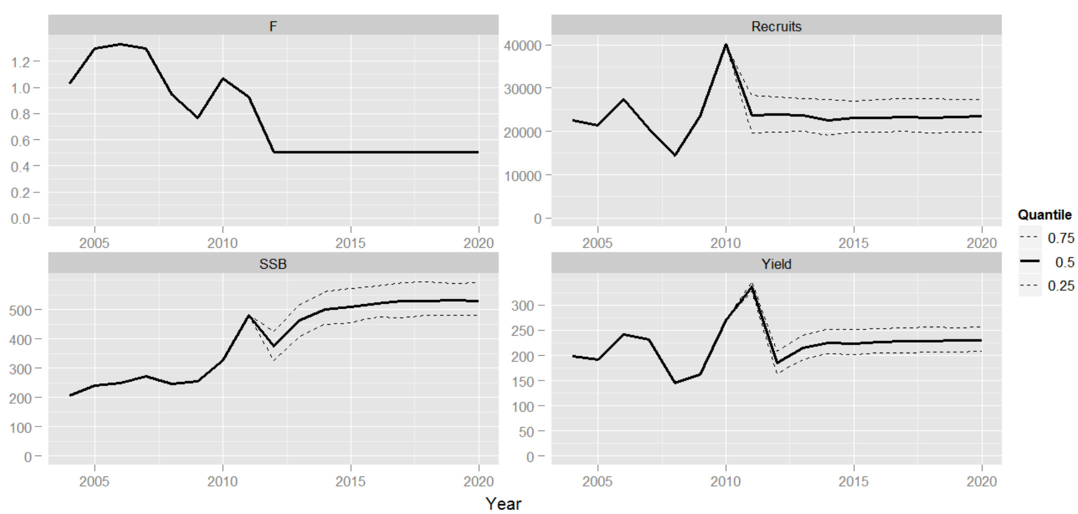


Fig. 7.9.2.3.1. Projection of F, recruits, SSB and yield under scenario 1 (constant F = F 0.1).

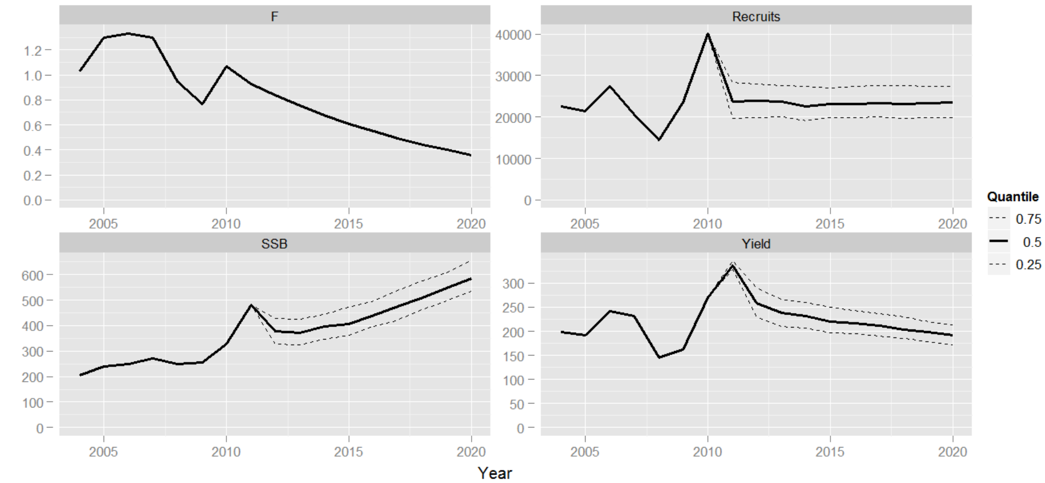


Fig. 7.9.2.3.2. Projection of F, recruits, SSB and yield under scenario 2.

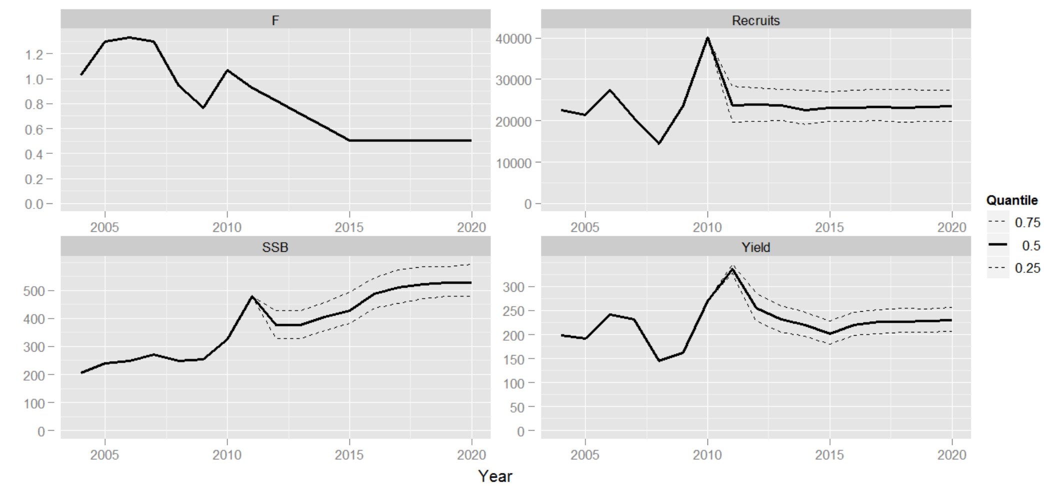


Fig. 7.9.2.3.3. Projection of F, recruits, SSB and yield under scenario 3.

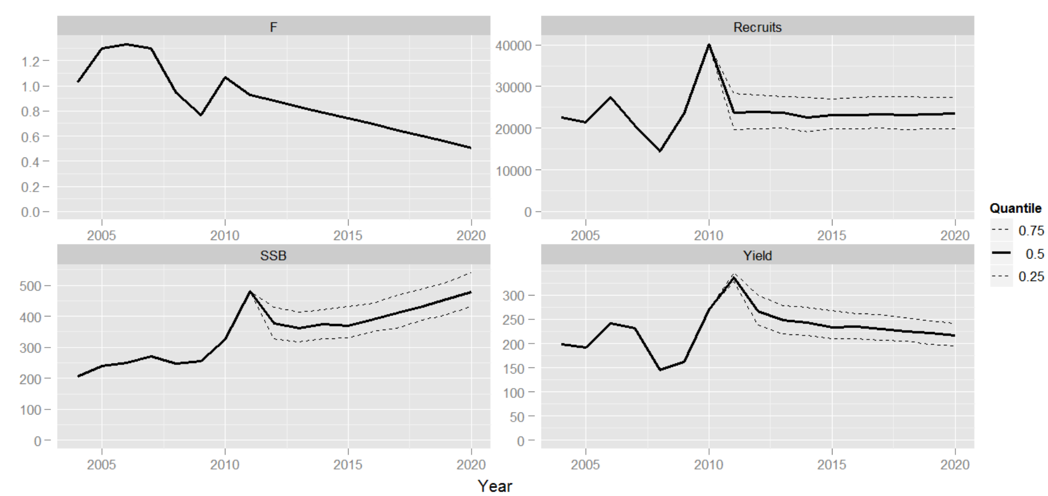


Fig. 7.9.2.3.4. Projection of F, recruits, SSB and yield under scenario 4.

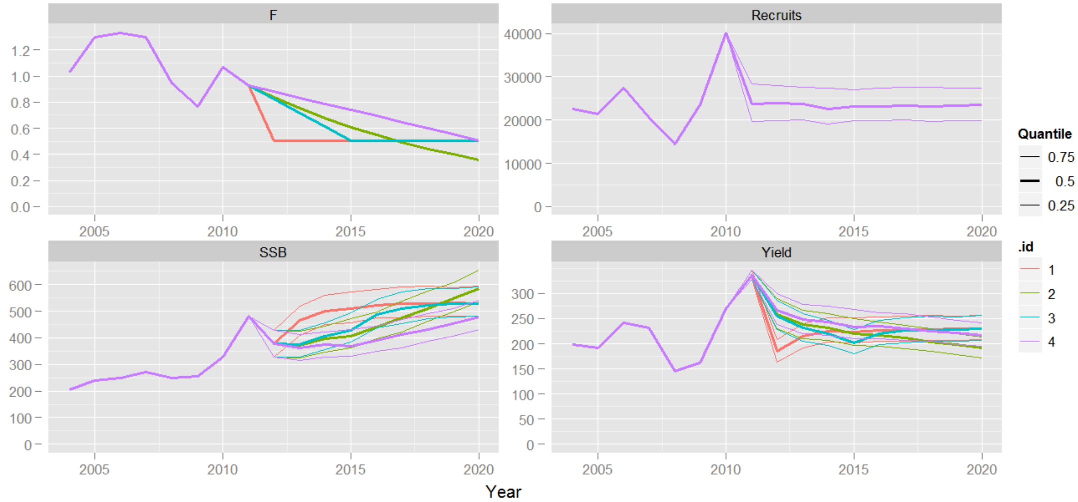


Fig. 7.9.2.3.4. Projections of F, recruits, SSB and yield under scenarios 1 to 4 2.

The scenario 2 (reduction of 10 % of F_{stq}) is the most optimistic at medium term considering increase of SSB with an increase of about 200 t in 2020. The decrease of F to $F_{0.1}$ the first year (scenario 1) showed some immediate increase of the SSB with a level at medium term lower than with scenario 2 and equal to the one of the scenario 3. The 4th scenario shows the lowest level of SSB at medium term.

Considering the catches, a decrease is observed for all scenarios and to the medium term for scenario 2 and 4. Considering the scenario 1, catches decrease the first year and increase immediately after to a steady state after 3 years.

STECF EWG 11-20 notes also that the red mullet is mainly caught in a mixed fisheries which imply a management plan being designed and implemented which takes into account both multi-species landings and fishing efforts constraints.

7.10 European hake (*Merluccius merluccius*) in GSA 9

7.10.1 Short term prediction 2011-2013

7.10.1.1 Method and justification

Short term predictions were implemented in R (www.r-project.org) using the FLR libraries and based on the results of Extended Survivors Analysis (XSA) carried out on 2005-2010 catch data collected under DCF.

7.10.1.2 Input parameters

The following data have been used to derive the input data for the short term projection of the pink shrimp stock in GSA9:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4+
2005-2010	Prop. Matures	0	0.21	0.9	1	1

PERIOD	Age	0	1	2	3	4+
2005-2010	M	1.3	0.6	0.46	0.41	0.25

F vector

F	0	1	2	3	4+
2005	1.3	2.07	1.61	1.96	1.96
2006	0.67	1.88	5.26	3.66	3.66
2007	0.68	2.41	1.87	1.76	1.76
2008	1.54	1.95	1.33	1.75	1.75
2009	1.66	1.71	1.19	1.7	1.7
2010	0.43	2.21	1.65	2.13	2.13

Weight-at-age in the stock

Mean weight in stock (kg)	0	1	2	3	4+
2005	0.01	0.1	0.43	1.34	2.54
2006	0.01	0.14	0.61	1.37	2.55
2007	0.01	0.13	0.6	1.36	2.53
2008	0.01	0.12	0.6	1.35	2.54

2009	0.01	0.1	0.45	1.36	2.64
2010	0.02	0.11	0.59	1.31	2.34

Weight-at-age in the catch

Mean weight in catch (kg)	0	1	2	3	4+
2005	0.01	0.1	0.43	1.34	2.54
2006	0.01	0.14	0.61	1.37	2.55
2007	0.01	0.13	0.6	1.36	2.53
2008	0.01	0.12	0.6	1.35	2.54
2009	0.01	0.1	0.45	1.36	2.64
2010	0.02	0.11	0.59	1.31	2.34

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2	3	4+
2005	75790	10367	670	55	24
2006	27005	9305	873	106	29
2007	20873	9923	836	3	32
2008	71150	7168	421	82	69
2009	69199	6267	489	81	65
2010	11930	5590	642	122	122

Number at age in the stock

Stock numbers at age (in thousands)	0	1	2	3	4+
2005	199590	16007	1055	79	31
2006	105700	14829	1105	134	33
2007	81395	14710	1245	4	45
2008	174020	11286	722	121	97
2009	163640	10282	884	121	92
2010	65375	8472	1000	170	158
2011	123000*	11590	510	121	13

*Geometric mean of the last three years (2008-2010).

Maturity was estimated as the mean of the last 3 years. M was calculated using the ProBiom method.

7.10.1.3 Results

A short term projection (Table 7.10.1.3.1), assuming an F_{stq} of 1.5 in 2011 and a recruitment of 123 million individuals, shows that:

- Fishing at the F_{stq} from 2010 to 2012 generates an increase in catch of about 23%, while the SSB remains more or less constant (+1.6%).

- Fishing at F_{MSY} (0.15) for the same time frame (2010-2012) generates a decrease in the catch of 79% and an increase of spawning stock biomass of more than the 200% from 2012 to 2013.

STECF EWG 11-20 advice considers the stock being highly overexploited, as F_{1-3} was estimated to range among 2.0 and 1.5 in the period 2005-2010. STECF-EWG 11-20 recommends that in 2013 fishing mortality should not exceed the value of F_{MSY} = 0.15, which corresponds to a catch of about 950 tons.

Outlook until 2013

Table 7.10.1.3.1. Short term forecast in different F scenarios computed for hake in GSA 9.

Basis: F(2010) = mean(F_{bar} 2005–2010); R(2011) = GM(2005–2010) = 123 (millions); F (2010) = 1.7; SSB(2012) = 820 t; Catch (2011) = 1970 t. weights in tons.

Rationale	F scenario	F factor	Catch 2012	Catch 2013	SSB 2013	Change SSB 2012 - 2013 (%)	Change Catch 2010 -2012 (%)
Zero catch	0.00	0.00	0	0	5224	277.9	-100.0
High long term yield (F_{01})	0.15	0.10	350	957	4464	226.2	-79.2
Status quo	1.50	1.00	2075	2091	1161	1.6	23.4
Different scenarios	0.30	0.20	641	1554	3848	184.3	-61.9
	0.60	0.40	1138	2166	2842	115.9	-32.3
	0.90	0.60	1527	2312	2104	65.7	-9.2
	1.20	0.80	1832	2243	1561	28.8	9.0
	1.81	1.20	2270	1919	866	-18.5	35.0
	2.11	1.40	2428	1759	648	-33.3	44.4
	2.41	1.60	2556	1621	486	-44.4	52.1
	2.71	1.80	2663	1508	365	-52.6	58.4
	3.01	2.00	2751	1419	275	-58.7	63.6
	0.00	0.00	0	0	5224	277.9	-100.0
	0.15	0.10	350	957	4464	226.2	-79.2
	1.50	1.00	2075	2091	1161	1.6	23.4
	0.30	0.20	641	1554	3848	184.3	-61.9
	0.60	0.40	1138	2166	2842	115.9	-32.3
	0.90	0.60	1527	2312	2104	65.7	-9.2
	1.20	0.80	1832	2243	1561	28.8	9.0
	1.81	1.20	2270	1919	866	-18.5	35.0
	2.11	1.40	2428	1759	648	-33.3	44.4
	2.41	1.60	2556	1621	486	-44.4	52.1

7.10.2 Medium term prediction

7.10.2.1 Method and justification

Medium term prediction from 2011 to 2020 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of stock assessment obtained using XSA. Medium term projections (10 years) were run assuming

1) a constant F = F_{MSY} since 2011;

2) a constant decrease of F by 10% per year;
3) a progressive decreasing trend of F toward F_{MSY} in 5 years (2015);
4) a progressive decreasing trend of F toward F_{MSY} in 10 years (2020).

The stock-recruitment relationship used geometric mean recruitment over the observed SSB range from 2008 to 2010. Runs were made with 500 simulations per run to try projecting stochastic recruitment, multiplying the recruitment by log-normally distributed noise with a mean 1 and standard deviation 0.3.

7.10.2.2 Input parameters

The maturity ogive, the natural mortality, the numbers of individuals and weight-at-age for the stock and for the catch were the same used in the short term forecast.

7.10.2.3 Results

In figure 7.10.2.3.1, the 25th, 50th, and 75th percentile are showed for the SSB, recruitment and catches in t from 2011 to 2020, considering a constant F = F_{MSY} since 2011.

In figure 7.10.2.3.2, the 25th, 50th, and 75th percentile are showed for the SSB, recruitment and catches in t from 2011 to 2020, considering a constant reduction of the F_{stq} of around 10% each year.

In figure 7.10.2.3.3, the 25th, 50th, and 75th percentile are showed for the SSB, recruitment and catches in t from 2011 to 2020, considering a reduction of the F_{stq} from 2011 to 2015, to reach F_{MSY} in 2015, and then a constant F = F_{MSY} until 2020.

In figure 7.10.2.3.4, the 25th, 50th, and 75th percentile are showed for the SSB, recruitment and catches in t from 2011 to 2020, considering a reduction of the F_{stq} from 2011 to reach F = F_{MSY} in 2020.

Landing data of European hake from 2005 to 2010 in the GSA09 are reported in the Table 7.10.2.3.1; a decreasing pattern since 2006 was observed in the data. In all the four scenarios of the medium-term forecasts assessed, the decrease of fishing mortality results in a sharp increase of both the SSB and the catch. Only in the 4th scenario, the Yield shows a decrease in the last years of the period investigated.

Table 7.10.2.3.1. Landings of pink shrimp in the GSA 9 (in tons).

year	2005	2006	2007	2008	2009	2010
DCF landings	1920	2330	1753	1330	1329	1484

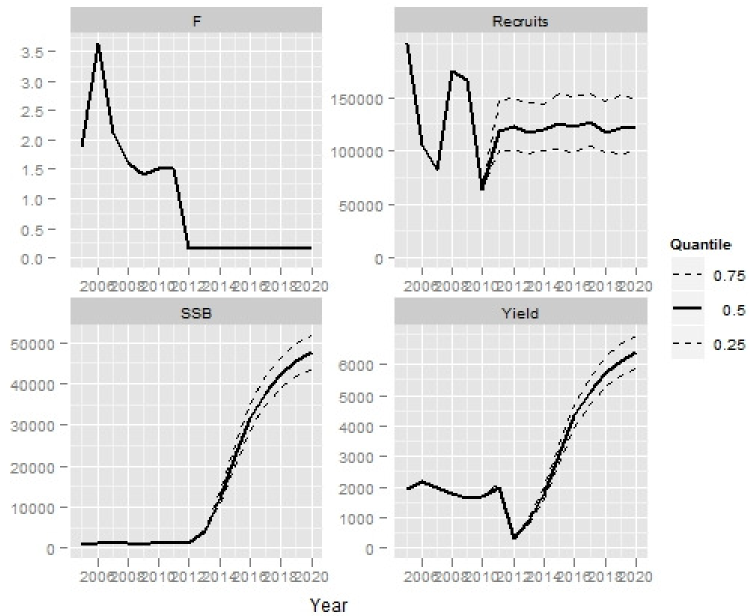


Fig. 7.10.2.3.1. Output of the medium term forecast computed for the European hake in GSA 9 reaching the F_{MSY} in 2011. Spawning Stock Biomass (SSB) and Yield are expressed in tonnes; recruits in thousands of individuals.

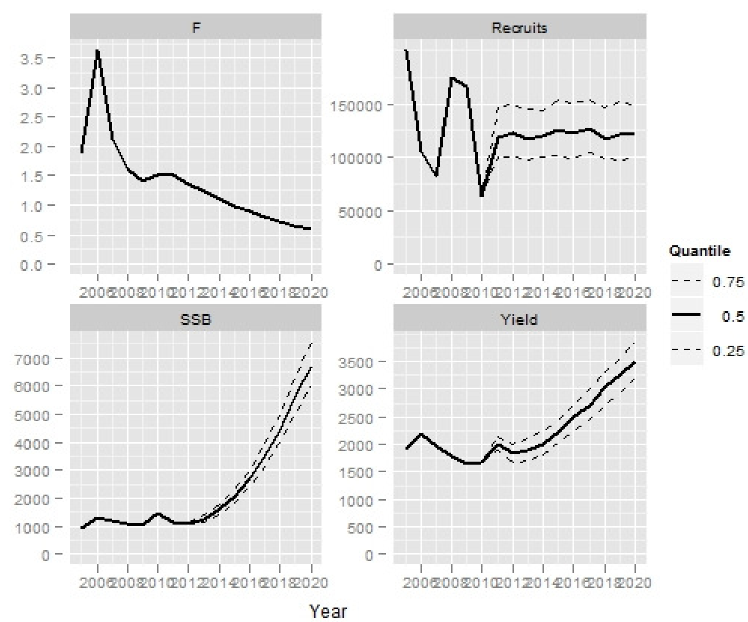


Fig. 7.10.2.3.2. Output of the medium term forecast computed for the European hake in GSA 9 with a constant decrease of F of 10% per year. Spawning Stock Biomass (SSB) and Yield are expressed in tonnes; recruits in thousands of individuals.

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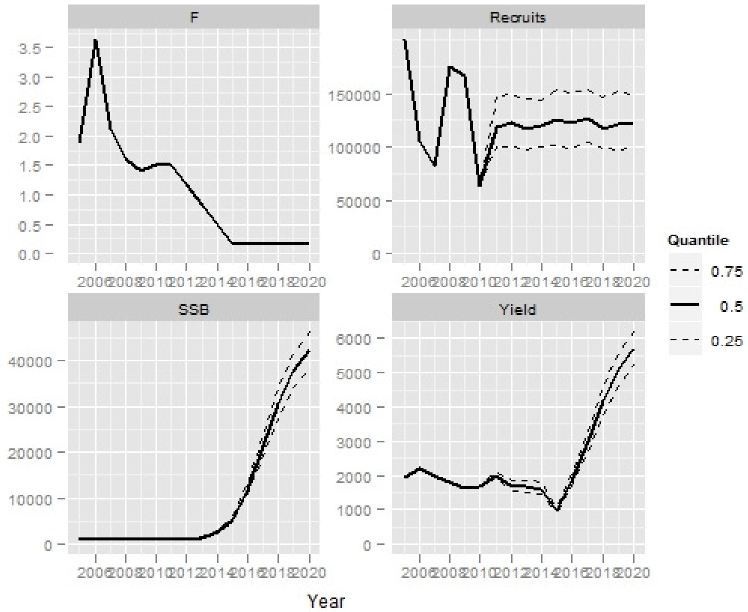


Fig. 7.10.2.3.3. Output of the medium term forecast computed for the European hake in GSA 9 reaching the F_{MSY} in 2015. Spawning Stock Biomass (SSB) and Yield are expressed in tonnes; recruits in thousands of individuals.

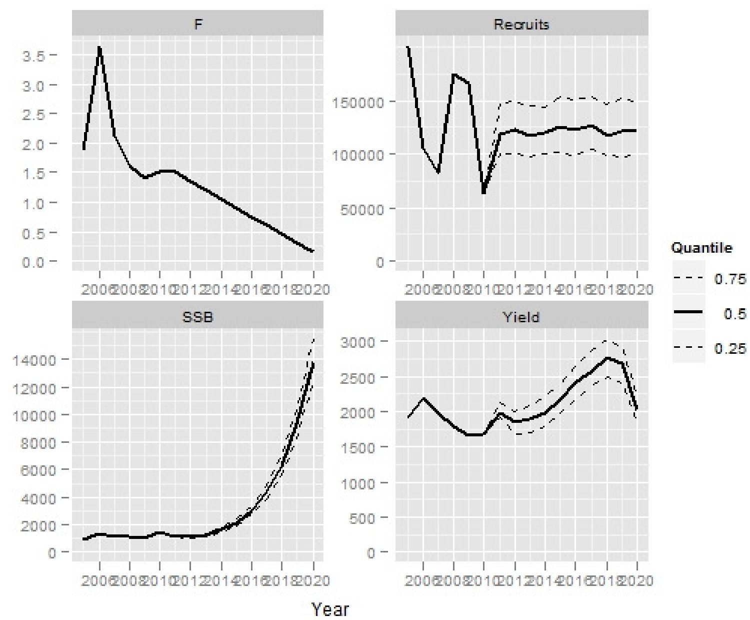


Fig. 7.10.2.3.4. Output of the medium term forecast computed for the European hake in GSA 9 reaching the F_{MSY} in 2020. Spawning Stock Biomass (SSB) and Yield are expressed in tonnes; recruits in thousands of individuals.

7.11 Red mullet (*Mullus barbatus*) in GSA 9

The ASPIC-P projection program was used for estimating trajectories of population biomass and fishing mortality rate at different rates of *F* with bias-corrected confidence intervals. The analyses were performed using as input the results of *ASPIC*. Input data for running ASPIC consisted in 2 sets of time series of total landings and fishing effort in two of the main ports of the GSA 9 and a time series of an index of abundance for the whole GSA 9 derived from MEDITS surveys.

MAIN ASPIC RESULTS

Current F estimated with ASPIC (2010) 0.54

F_{MSY} Fishing mortality rate at MSY 0.474

$B./B_{MSY}$ Ratio: $B(2010)/B_{MSY}$ 0.584

$F./F_{MSY}$ Ratio: $F(2010)/F_{MSY}$ 1.12 (1.138 in 2009)

7.11.1 Short term prediction 2010-2012

7.11.1.1 Method and justification

Short term prediction for 2011 and 2012 was implemented in ASPIC-P.

As in the last years the biomass is strongly increasing, no decrease in yields are predicted with any of the proposed scenarios, even though reductions in *F* are assumed, because they are likely compensated by these higher abundances. A decrease can be only observed in 2020 assuming a decrease in *F* of 10% each year, considering that at this time *F* will be reduced at about 0.22. By assuming a decrease of 10% each year the fishing mortality rate $F_{0.1}$ will be reached in 2012.

	F	B 2010	B 2011	B 2015	B 2020	Y 2010	Y 2011	Y 2012	Y 2015	Y 2020
no fishing	0		18.95%	273.79%	282.32%					
status quo	0.54		18.95%	72.02%	67.04%		15.81%	28.04%	46.66%	52.46%
set F01. in 2015			18.95%	72.02%	92.17%		14.17%	26.29%	41.86%	54.51%
set F01. in 2020			18.95%	67.12%	87.72%		14.99%	26.29%	44.61%	51.76%
decrease F of 10%/year			18.95%	113.72%	190.65%		7.32%	14.29%	21.08%	-5.44%
F0.1 from starting	0.47		18.95%	82.24%	92.87%		5.56%	22.78%	48.36%	54.92%

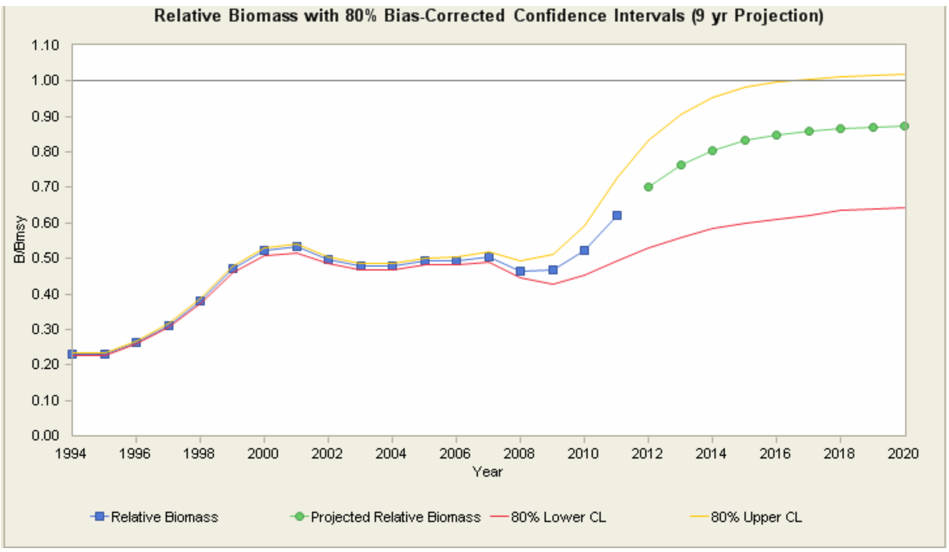
7.11.1.2 Input parameters

The data used is the output of *ASPIC*. The used dynamic biomass model, which is not an analytic model, does not allow doing any consideration on the size of the spawning stock at different effort regimes but only for the whole stock, neither to assess the influence of any change in selectivity.

7.11.2 Medium term prediction 2012-2020

Several scenarios were simulated by assuming:

- current F to be kept unchanged up to year 2025 (status quo F=0.54),
- a progressive reduction of F by 10% each year from the current to F0.1 ,
- getting the F0.1 rate in 2015 and in 2020,
- fishing from the starting year (2012) at the F0.1 rate (F=0.47),
- assuming F=0.



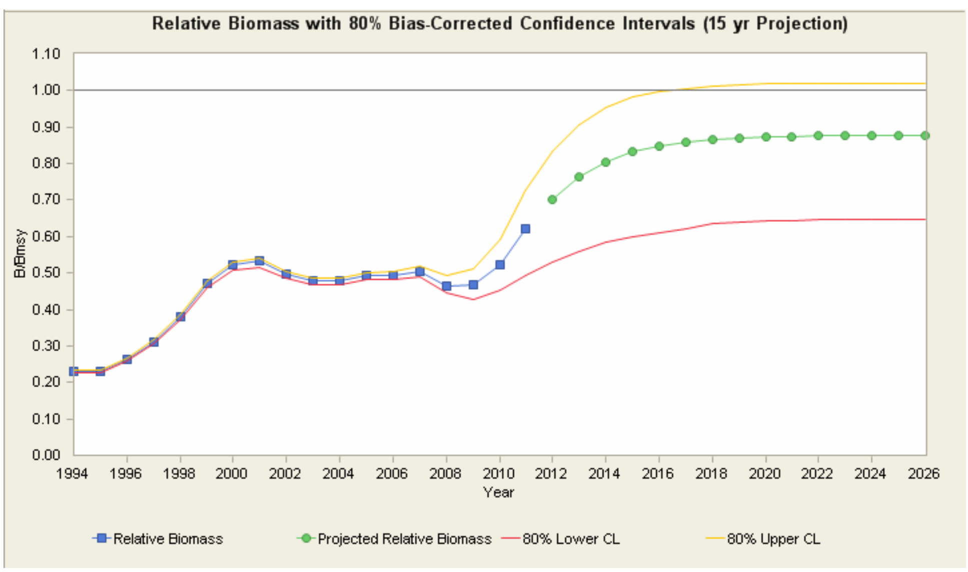
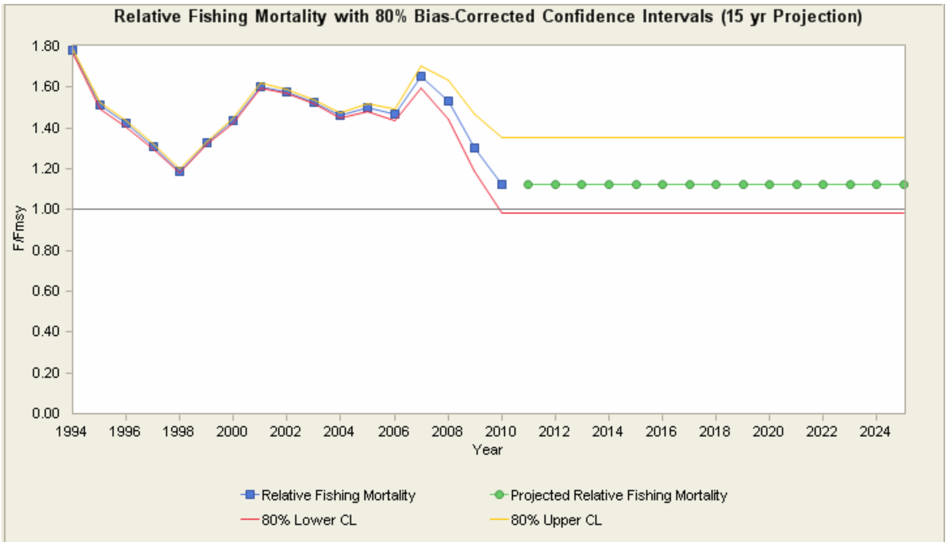


Fig. 7.11.2.1. Evolution of the relative Biomass B/B_{MSY} with F_{stq}.



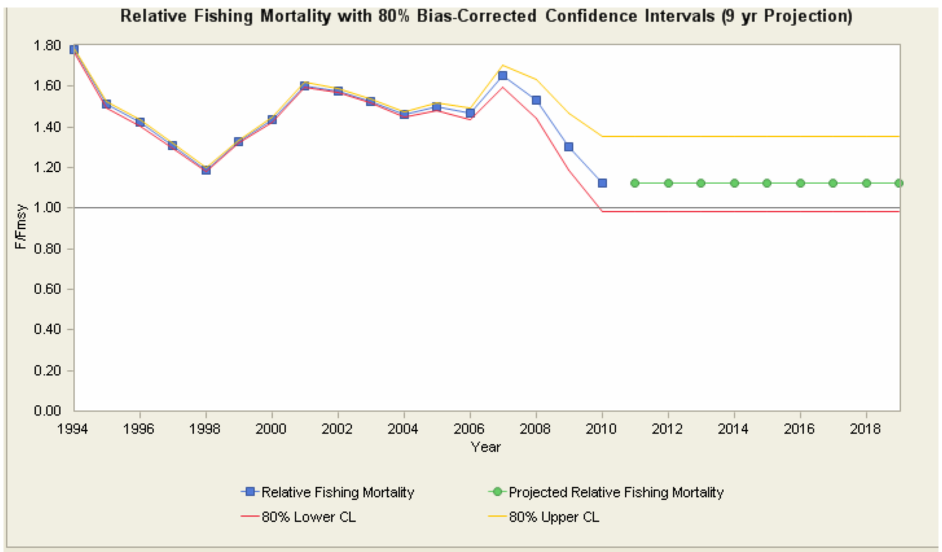


Fig. 7.11.2.2. Evolution of the relative fishing mortality with F_{stq}.

Simulation results indicate that by keeping unchanged the current F it is not possible to reach the B_{MSY} in 2020.

TRAJECTORY OF RELATIVE BIOMASS B/Bmsy (BOOTSTRAPPED)

Year	Point estimate	Estimated bias	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
1994	2.307E-01	2.984E-03	1.29%	2.266E-01	2.332E-01	2.295E-01	2.313E-01	1.745E-03	0.008
1995	2.291E-01	2.599E-03	1.13%	2.265E-01	2.333E-01	2.283E-01	2.301E-01	1.831E-03	0.008
1996	2.632E-01	3.273E-03	1.24%	2.597E-01	2.683E-01	2.621E-01	2.645E-01	2.382E-03	0.009
1997	3.107E-01	4.560E-03	1.47%	3.064E-01	3.173E-01	3.094E-01	3.124E-01	2.978E-03	0.010
1998	3.784E-01	6.850E-03	1.81%	3.724E-01	3.861E-01	3.766E-01	3.802E-01	3.616E-03	0.010
1999	4.717E-01	1.022E-02	2.17%	4.606E-01	4.787E-01	4.687E-01	4.730E-01	4.359E-03	0.009
2000	5.218E-01	1.186E-02	2.27%	5.066E-01	5.287E-01	5.169E-01	5.228E-01	5.898E-03	0.011
2001	5.335E-01	1.196E-02	2.24%	5.167E-01	5.403E-01	5.276E-01	5.345E-01	6.867E-03	0.013
2002	4.987E-01	1.059E-02	2.12%	4.846E-01	5.050E-01	4.939E-01	4.996E-01	5.693E-03	0.011
2003	4.801E-01	9.949E-03	2.07%	4.677E-01	4.866E-01	4.765E-01	4.812E-01	4.767E-03	0.010
2004	4.787E-01	9.964E-03	2.08%	4.671E-01	4.853E-01	4.751E-01	4.801E-01	4.924E-03	0.010

2005	4.926E-01	1.051E-02	2.13%	4.817E-01	5.013E-01	4.884E-01	4.948E-01	6.395E-03	0.013
2006	4.939E-01	1.064E-02	2.15%	4.834E-01	5.061E-01	4.884E-01	4.981E-01	9.652E-03	0.020
2007	5.027E-01	1.109E-02	2.21%	4.887E-01	5.191E-01	4.939E-01	5.075E-01	1.358E-02	0.027
2008	4.655E-01	1.014E-02	2.18%	4.453E-01	4.936E-01	4.533E-01	4.763E-01	2.305E-02	0.050
2009	4.664E-01	1.047E-02	2.25%	4.285E-01	5.119E-01	4.444E-01	4.856E-01	4.116E-02	0.088
2010	5.231E-01	1.166E-02	2.23%	4.541E-01	5.915E-01	4.813E-01	5.563E-01	7.503E-02	0.143
2011	6.223E-01	1.056E-02	1.70%	4.946E-01	7.265E-01	5.462E-01	6.705E-01	1.243E-01	0.200
2012	7.030E-01	7.355E-03	1.05%	5.303E-01	8.333E-01	6.043E-01	7.647E-01	1.605E-01	0.228
2013	7.629E-01	3.101E-03	0.41%	5.583E-01	9.045E-01	6.472E-01	8.324E-01	1.852E-01	0.243
2014	8.044E-01	-9.927E-04	-0.12%	5.833E-01	9.527E-01	6.814E-01	8.780E-01	1.965E-01	0.244
2015	8.318E-01	-4.267E-03	-0.51%	5.996E-01	9.833E-01	7.095E-01	9.072E-01	1.977E-01	0.238
2016	8.493E-01	-6.596E-03	-0.78%	6.115E-01	9.966E-01	7.210E-01	9.222E-01	2.012E-01	0.237
2017	8.602E-01	-8.125E-03	-0.94%	6.199E-01	1.005E+00	7.315E-01	9.329E-01	2.014E-01	0.234
2018	8.670E-01	-9.072E-03	-1.05%	6.344E-01	1.012E+00	7.425E-01	9.425E-01	2.000E-01	0.231
2019	8.712E-01	-9.630E-03	-1.11%	6.387E-01	1.016E+00	7.468E-01	9.452E-01	1.984E-01	0.228
2020	8.737E-01	-9.941E-03	-1.14%	6.417E-01	1.018E+00	7.496E-01	9.472E-01	1.976E-01	0.226
2021	8.752E-01	-1.011E-02	-1.15%	6.437E-01	1.018E+00	7.514E-01	9.485E-01	1.970E-01	0.225
2022	8.762E-01	-1.018E-02	-1.16%	6.452E-01	1.018E+00	7.526E-01	9.490E-01	1.964E-01	0.224
2023	8.767E-01	-1.022E-02	-1.17%	6.462E-01	1.018E+00	7.533E-01	9.493E-01	1.960E-01	0.224
2024	8.771E-01	-1.022E-02	-1.17%	6.469E-01	1.018E+00	7.538E-01	9.495E-01	1.957E-01	0.223
2025	8.773E-01	-1.022E-02	-1.17%	6.473E-01	1.019E+00	7.541E-01	9.496E-01	1.955E-01	0.223
2026	8.774E-01	-1.021E-02	-1.16%	6.477E-01	1.019E+00	7.543E-01	9.496E-01	1.953E-01	0.223

TRAJECTORY OF RELATIVE FISHING MORTALITY RATE F/Fmsy (BOOTSTRAPPED)

Year	Point estimate	Estimated bias	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	quartile range	Relative IQ range
1994	1.782E+00	-8.686E-04	-0.05%	1.765E+00	1.790E+00	1.776E+00	1.784E+00	7.905E-03	0.004
1995	1.511E+00	-1.719E-04	-0.01%	1.491E+00	1.525E+00	1.505E+00	1.516E+00	1.064E-02	0.007
1996	1.423E+00	-1.547E-03	-0.11%	1.402E+00	1.436E+00	1.416E+00	1.427E+00	1.035E-02	0.007
1997	1.311E+00	-3.899E-03	-0.30%	1.295E+00	1.322E+00	1.306E+00	1.315E+00	8.501E-03	0.006
1998	1.189E+00	-6.713E-03	-0.56%	1.179E+00	1.197E+00	1.187E+00	1.191E+00	4.764E-03	0.004
1999	1.326E+00	-9.834E-03	-0.74%	1.320E+00	1.337E+00	1.325E+00	1.329E+00	4.309E-03	0.003
2000	1.433E+00	-1.129E-02	-0.79%	1.426E+00	1.449E+00	1.432E+00	1.439E+00	6.716E-03	0.005
2001	1.603E+00	-1.178E-02	-0.74%	1.594E+00	1.619E+00	1.601E+00	1.609E+00	7.650E-03	0.005
2002	1.578E+00	-1.072E-02	-0.68%	1.570E+00	1.591E+00	1.576E+00	1.582E+00	5.920E-03	0.004
2003	1.526E+00	-1.017E-02	-0.67%	1.516E+00	1.536E+00	1.523E+00	1.530E+00	7.465E-03	0.005
2004	1.464E+00	-1.024E-02	-0.70%	1.451E+00	1.475E+00	1.460E+00	1.470E+00	1.054E-02	0.007
2005	1.502E+00	-1.096E-02	-0.73%	1.482E+00	1.519E+00	1.495E+00	1.512E+00	1.704E-02	0.011
2006	1.471E+00	-1.131E-02	-0.77%	1.438E+00	1.495E+00	1.458E+00	1.486E+00	2.826E-02	0.019
2007	1.652E+00	-1.222E-02	-0.74%	1.596E+00	1.705E+00	1.626E+00	1.684E+00	5.828E-02	0.035
2008	1.531E+00	-9.236E-03	-0.60%	1.444E+00	1.635E+00	1.489E+00	1.594E+00	1.053E-01	0.069
2009	1.304E+00	-2.439E-03	-0.19%	1.187E+00	1.470E+00	1.246E+00	1.400E+00	1.547E-01	0.119
2010	1.122E+00	1.017E-02	0.91%	9.815E-01	1.352E+00	1.050E+00	1.245E+00	1.949E-01	0.174
2011	1.122E+00	1.017E-02	0.91%	9.815E-01	1.352E+00	1.050E+00	1.245E+00	1.949E-01	0.174
2012	1.122E+00	1.017E-02	0.91%	9.815E-01	1.352E+00	1.050E+00	1.245E+00	1.949E-01	0.174
2013	1.122E+00	1.017E-02	0.91%	9.815E-01	1.352E+00	1.050E+00	1.245E+00	1.949E-01	0.174
2014	1.122E+00	1.017E-02	0.91%	9.815E-01	1.352E+00	1.050E+00	1.245E+00	1.949E-01	0.174
2015	1.122E+00	1.017E-02	0.91%	9.815E-01	1.352E+00	1.050E+00	1.245E+00	1.949E-01	0.174
2016	1.122E+00	1.017E-02	0.91%	9.815E-01	1.352E+00	1.050E+00	1.245E+00	1.949E-01	0.174
2017	1.122E+00	1.017E-02	0.91%	9.815E-01	1.352E+00	1.050E+00	1.245E+00	1.949E-01	0.174
2018	1.122E+00	1.017E-02	0.91%	9.815E-01	1.352E+00	1.050E+00	1.245E+00	1.949E-01	0.174
2019	1.122E+00	1.017E-02	0.91%	9.815E-01	1.352E+00	1.050E+00	1.245E+00	1.949E-01	0.174
2020	1.122E+00	1.017E-02	0.91%	9.815E-01	1.352E+00	1.050E+00	1.245E+00	1.949E-01	0.174
2021	1.122E+00	1.017E-02	0.91%	9.815E-01	1.352E+00	1.050E+00	1.245E+00	1.949E-01	0.174
2022	1.122E+00	1.017E-02	0.91%	9.815E-01	1.352E+00	1.050E+00	1.245E+00	1.949E-01	0.174
2023	1.122E+00	1.017E-02	0.91%	9.815E-01	1.352E+00	1.050E+00	1.245E+00	1.949E-01	0.174
2024	1.122E+00	1.017E-02	0.91%	9.815E-01	1.352E+00	1.050E+00	1.245E+00	1.949E-01	0.174
2025	1.122E+00	1.017E-02	0.91%	9.815E-01	1.352E+00	1.050E+00	1.245E+00	1.949E-01	0.174

TABLE OF PROJECTED YIELDS

2011	1.978E+05	-1.805E+03	-0.91%	1.867E+05	2.028E+05	1.927E+05	2.009E+05	8.201E+03	0.041
2012	2.187E+05	-3.689E+03	-1.69%	1.985E+05	2.265E+05	2.093E+05	2.234E+05	1.410E+04	0.064
2013	2.337E+05	-5.367E+03	-2.30%	2.095E+05	2.418E+05	2.237E+05	2.395E+05	1.580E+04	0.068
2014	2.439E+05	-6.669E+03	-2.73%	2.186E+05	2.517E+05	2.354E+05	2.499E+05	1.459E+04	0.060
2015	2.505E+05	-7.579E+03	-3.03%	2.276E+05	2.573E+05	2.427E+05	2.559E+05	1.317E+04	0.053
2016	2.546E+05	-8.165E+03	-3.21%	2.346E+05	2.616E+05	2.493E+05	2.597E+05	1.038E+04	0.041
2017	2.572E+05	-8.521E+03	-3.31%	2.380E+05	2.637E+05	2.521E+05	2.617E+05	9.637E+03	0.037
2018	2.588E+05	-8.724E+03	-3.37%	2.412E+05	2.660E+05	2.546E+05	2.632E+05	8.668E+03	0.033
2019	2.598E+05	-8.833E+03	-3.40%	2.431E+05	2.670E+05	2.561E+05	2.639E+05	7.803E+03	0.030
2020	2.604E+05	-8.887E+03	-3.41%	2.443E+05	2.683E+05	2.569E+05	2.644E+05	7.535E+03	0.029
2021	2.608E+05	-8.909E+03	-3.42%	2.455E+05	2.687E+05	2.575E+05	2.647E+05	7.278E+03	0.028
2022	2.610E+05	-8.916E+03	-3.42%	2.471E+05	2.696E+05	2.579E+05	2.649E+05	7.009E+03	0.027
2023	2.611E+05	-8.915E+03	-3.41%	2.473E+05	2.698E+05	2.581E+05	2.650E+05	6.903E+03	0.026
2024	2.612E+05	-8.910E+03	-3.41%	2.475E+05	2.698E+05	2.581E+05	2.650E+05	6.932E+03	0.027
2025	2.613E+05	-8.905E+03	-3.41%	2.475E+05	2.699E+05	2.581E+05	2.650E+05	6.911E+03	0.026

TRAJECTORY OF ABSOLUTE BIOMASS (BOOTSTRAPPED)

Year	Point estimate	Estimated bias	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	quartile range	Relative IQ range
1994	1.070E+05	-1.529E+03	-1.43%	1.032E+05	1.133E+05	1.060E+05	1.096E+05	3.616E+03	0.034
1995	1.063E+05	-1.641E+03	-1.54%	1.018E+05	1.130E+05	1.051E+05	1.090E+05	3.943E+03	0.037
1996	1.221E+05	-1.801E+03	-1.48%	1.168E+05	1.303E+05	1.206E+05	1.254E+05	4.731E+03	0.039
1997	1.442E+05	-1.920E+03	-1.33%	1.383E+05	1.542E+05	1.428E+05	1.486E+05	5.839E+03	0.041
1998	1.755E+05	-1.943E+03	-1.11%	1.687E+05	1.870E+05	1.738E+05	1.801E+05	6.324E+03	0.036
1999	2.189E+05	-1.889E+03	-0.86%	2.114E+05	2.314E+05	2.170E+05	2.238E+05	6.707E+03	0.031
2000	2.421E+05	-1.898E+03	-0.78%	2.345E+05	2.542E+05	2.400E+05	2.470E+05	6.924E+03	0.029
2001	2.475E+05	-1.971E+03	-0.80%	2.401E+05	2.595E+05	2.457E+05	2.523E+05	6.650E+03	0.027
2002	2.314E+05	-2.025E+03	-0.88%	2.245E+05	2.436E+05	2.299E+05	2.366E+05	6.709E+03	0.029
2003	2.227E+05	-2.022E+03	-0.91%	2.158E+05	2.348E+05	2.211E+05	2.277E+05	6.615E+03	0.030
2004	2.221E+05	-1.996E+03	-0.90%	2.151E+05	2.348E+05	2.204E+05	2.270E+05	6.546E+03	0.029
2005	2.286E+05	-1.954E+03	-0.85%	2.219E+05	2.420E+05	2.270E+05	2.345E+05	7.526E+03	0.033
2006	2.292E+05	-1.897E+03	-0.83%	2.223E+05	2.424E+05	2.274E+05	2.354E+05	8.061E+03	0.035
2007	2.332E+05	-1.797E+03	-0.77%	2.249E+05	2.462E+05	2.299E+05	2.400E+05	1.010E+04	0.043
2008	2.160E+05	-1.628E+03	-0.75%	2.039E+05	2.319E+05	2.102E+05	2.235E+05	1.330E+04	0.062
2009	2.164E+05	-1.444E+03	-0.67%	1.982E+05	2.436E+05	2.090E+05	2.297E+05	2.072E+04	0.096
2010	2.427E+05	-1.651E+03	-0.68%	2.125E+05	2.830E+05	2.297E+05	2.632E+05	3.348E+04	0.138
2011	2.887E+05	-3.360E+03	-1.16%	2.374E+05	3.443E+05	2.651E+05	3.168E+05	5.174E+04	0.179
2012	3.262E+05	-5.631E+03	-1.73%	2.633E+05	3.991E+05	2.977E+05	3.638E+05	6.609E+04	0.203
2013	3.540E+05	-8.067E+03	-2.28%	2.813E+05	4.346E+05	3.202E+05	3.965E+05	7.630E+04	0.216
2014	3.732E+05	-1.022E+04	-2.74%	2.941E+05	4.579E+05	3.367E+05	4.171E+05	8.044E+04	0.216
2015	3.859E+05	-1.187E+04	-3.08%	3.038E+05	4.720E+05	3.495E+05	4.327E+05	8.323E+04	0.216
2016	3.940E+05	-1.302E+04	-3.30%	3.114E+05	4.802E+05	3.575E+05	4.413E+05	8.380E+04	0.213
2017	3.991E+05	-1.376E+04	-3.45%	3.143E+05	4.844E+05	3.626E+05	4.464E+05	8.378E+04	0.210
2018	4.023E+05	-1.421E+04	-3.53%	3.170E+05	4.867E+05	3.657E+05	4.494E+05	8.362E+04	0.208
2019	4.042E+05	-1.447E+04	-3.58%	3.183E+05	4.874E+05	3.672E+05	4.508E+05	8.363E+04	0.207
2020	4.054E+05	-1.462E+04	-3.61%	3.189E+05	4.881E+05	3.685E+05	4.516E+05	8.313E+04	0.205
2021	4.061E+05	-1.470E+04	-3.62%	3.199E+05	4.883E+05	3.692E+05	4.524E+05	8.325E+04	0.205
2022	4.065E+05	-1.473E+04	-3.62%	3.205E+05	4.887E+05	3.703E+05	4.529E+05	8.264E+04	0.203
2023	4.068E+05	-1.475E+04	-3.63%	3.210E+05	4.888E+05	3.707E+05	4.530E+05	8.236E+04	0.202
2024	4.069E+05	-1.475E+04	-3.62%	3.213E+05	4.889E+05	3.709E+05	4.531E+05	8.221E+04	0.202
2025	4.070E+05	-1.475E+04	-3.62%	3.215E+05	4.889E+05	3.711E+05	4.532E+05	8.211E+04	0.202
2026	4.071E+05	-1.474E+04	-3.62%	3.216E+05	4.889E+05	3.712E+05	4.532E+05	8.204E+04	0.202

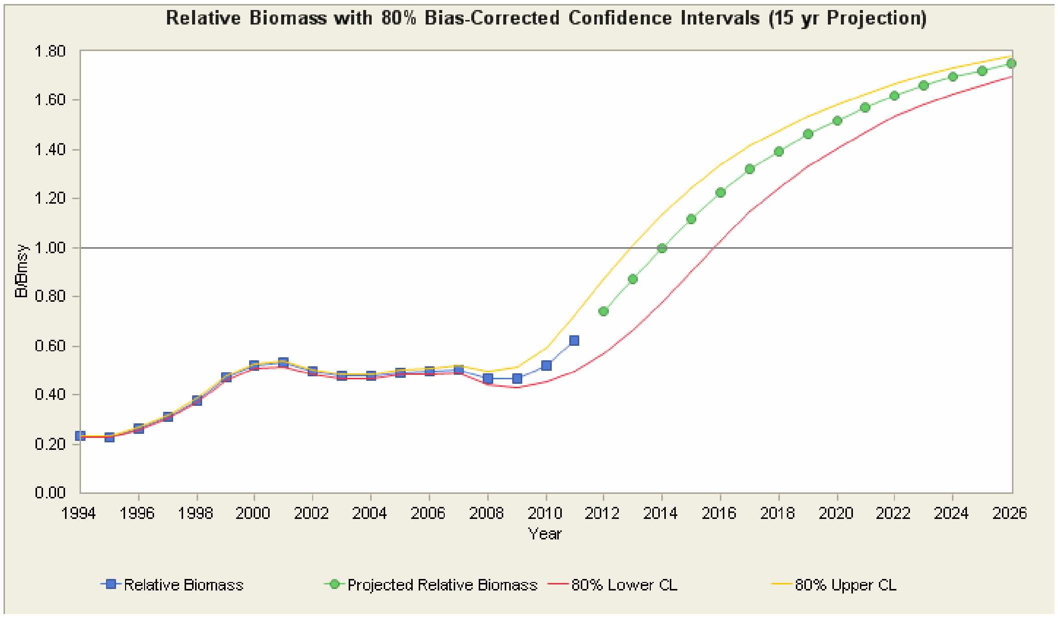


Fig. 7.11.2.3 Evolution of the relative biomass assuming 10% reduction each year from F current.

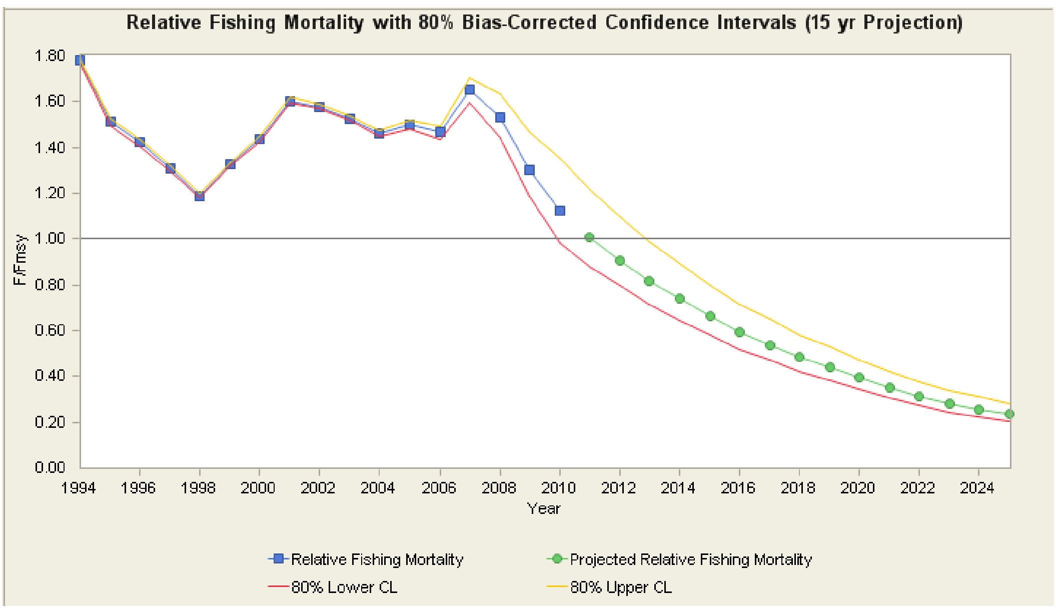


Fig. 7.11.2.4. Evolution of the relative fishing mortality assuming 10% reduction each year from F current.

TABLE OF PROJECTED YIELDS

2011	1.833E+05	-1.570E+03	-0.86%	1.737E+05	1.872E+05	1.787E+05	1.857E+05	6.930E+03	0.038
2012	1.952E+05	-2.955E+03	-1.51%	1.825E+05	1.990E+05	1.899E+05	1.978E+05	7.813E+03	0.040
2013	2.042E+05	-3.956E+03	-1.94%	1.990E+05	2.080E+05	2.030E+05	2.062E+05	3.199E+03	0.016
2014	2.090E+05	-4.357E+03	-2.08%	2.082E+05	2.176E+05	2.092E+05	2.151E+05	5.880E+03	0.028
2015	2.068E+05	-4.112E+03	-1.99%	2.006E+05	2.107E+05	2.051E+05	2.090E+05	3.938E+03	0.019
2016	2.016E+05	-3.522E+03	-1.75%	1.883E+05	2.087E+05	1.960E+05	2.066E+05	1.055E+04	0.052
2017	1.946E+05	-2.851E+03	-1.46%	1.801E+05	2.079E+05	1.879E+05	2.028E+05	1.485E+04	0.076
2018	1.836E+05	-2.205E+03	-1.20%	1.680E+05	2.008E+05	1.762E+05	1.935E+05	1.732E+04	0.094
2019	1.737E+05	-1.707E+03	-0.98%	1.576E+05	1.932E+05	1.658E+05	1.850E+05	1.917E+04	0.110

2020	1.615E+05	-1.309E+03	-0.81%	1.455E+05	1.819E+05	1.535E+05	1.732E+05	1.970E+04	0.122
2021	1.476E+05	-9.917E+02	-0.67%	1.322E+05	1.681E+05	1.398E+05	1.593E+05	1.951E+04	0.132
2022	1.370E+05	-7.718E+02	-0.56%	1.222E+05	1.573E+05	1.295E+05	1.486E+05	1.911E+04	0.140
2023	1.251E+05	-5.981E+02	-0.48%	1.112E+05	1.447E+05	1.182E+05	1.362E+05	1.802E+04	0.144
2024	1.173E+05	-4.847E+02	-0.41%	1.040E+05	1.363E+05	1.107E+05	1.281E+05	1.733E+04	0.148
2025	1.088E+05	-3.950E+02	-0.36%	9.614E+04	1.269E+05	1.025E+05	1.190E+05	1.648E+04	0.151

TRAJECTORY OF ABSOLUTE BIOMASS (BOOTSTRAPPED)

Year	Point estimate	Estimated bias	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	quartile range	Relative IQ range
1994	1.070E+05	-1.529E+03	-1.43%	1.032E+05	1.133E+05	1.060E+05	1.096E+05	3.616E+03	0.034
1995	1.063E+05	-1.641E+03	-1.54%	1.018E+05	1.130E+05	1.051E+05	1.090E+05	3.943E+03	0.037
1996	1.221E+05	-1.801E+03	-1.48%	1.168E+05	1.303E+05	1.206E+05	1.254E+05	4.731E+03	0.039
1997	1.442E+05	-1.920E+03	-1.33%	1.383E+05	1.542E+05	1.428E+05	1.486E+05	5.839E+03	0.041
1998	1.755E+05	-1.943E+03	-1.11%	1.687E+05	1.870E+05	1.738E+05	1.801E+05	6.324E+03	0.036
1999	2.189E+05	-1.889E+03	-0.86%	2.114E+05	2.314E+05	2.170E+05	2.238E+05	6.707E+03	0.031
2000	2.421E+05	-1.898E+03	-0.78%	2.345E+05	2.542E+05	2.400E+05	2.470E+05	6.924E+03	0.029
2001	2.475E+05	-1.971E+03	-0.80%	2.401E+05	2.595E+05	2.457E+05	2.523E+05	6.650E+03	0.027
2002	2.314E+05	-2.025E+03	-0.88%	2.245E+05	2.436E+05	2.299E+05	2.366E+05	6.709E+03	0.029
2003	2.227E+05	-2.022E+03	-0.91%	2.158E+05	2.348E+05	2.211E+05	2.277E+05	6.615E+03	0.030
2004	2.221E+05	-1.996E+03	-0.90%	2.151E+05	2.348E+05	2.204E+05	2.270E+05	6.546E+03	0.029
2005	2.286E+05	-1.954E+03	-0.85%	2.219E+05	2.420E+05	2.270E+05	2.345E+05	7.526E+03	0.033
2006	2.292E+05	-1.897E+03	-0.83%	2.223E+05	2.424E+05	2.274E+05	2.354E+05	8.061E+03	0.035
2007	2.332E+05	-1.797E+03	-0.77%	2.249E+05	2.462E+05	2.299E+05	2.400E+05	1.010E+04	0.043
2008	2.160E+05	-1.628E+03	-0.75%	2.039E+05	2.319E+05	2.102E+05	2.235E+05	1.330E+04	0.062
2009	2.164E+05	-1.444E+03	-0.67%	1.982E+05	2.436E+05	2.090E+05	2.297E+05	2.072E+04	0.096
2010	2.427E+05	-1.651E+03	-0.68%	2.125E+05	2.830E+05	2.297E+05	2.632E+05	3.348E+04	0.138
2011	2.887E+05	-3.360E+03	-1.16%	2.374E+05	3.443E+05	2.651E+05	3.168E+05	5.174E+04	0.179
2012	3.439E+05	-5.971E+03	-1.74%	2.807E+05	4.163E+05	3.151E+05	3.816E+05	6.651E+04	0.193
2013	4.040E+05	-9.412E+03	-2.33%	3.311E+05	4.834E+05	3.704E+05	4.463E+05	7.590E+04	0.188
2014	4.638E+05	-1.291E+04	-2.78%	3.850E+05	5.422E+05	4.300E+05	5.073E+05	7.731E+04	0.167
2015	5.187E+05	-1.566E+04	-3.02%	4.417E+05	5.946E+05	4.879E+05	5.635E+05	7.560E+04	0.146
2016	5.686E+05	-1.742E+04	-3.06%	5.007E+05	6.429E+05	5.451E+05	6.116E+05	6.652E+04	0.117
2017	6.118E+05	-1.832E+04	-2.99%	5.496E+05	6.817E+05	5.902E+05	6.506E+05	6.046E+04	0.099
2018	6.476E+05	-1.869E+04	-2.89%	5.889E+05	7.106E+05	6.256E+05	6.808E+05	5.521E+04	0.085
2019	6.792E+05	-1.887E+04	-2.78%	6.256E+05	7.386E+05	6.600E+05	7.105E+05	5.049E+04	0.074
2020	7.054E+05	-1.899E+04	-2.69%	6.550E+05	7.623E+05	6.863E+05	7.347E+05	4.845E+04	0.069
2021	7.291E+05	-1.913E+04	-2.62%	6.836E+05	7.850E+05	7.123E+05	7.587E+05	4.637E+04	0.064
2022	7.515E+05	-1.931E+04	-2.57%	7.083E+05	8.058E+05	7.356E+05	7.796E+05	4.402E+04	0.059
2023	7.702E+05	-1.949E+04	-2.53%	7.298E+05	8.239E+05	7.568E+05	7.976E+05	4.087E+04	0.053
2024	7.872E+05	-1.968E+04	-2.50%	7.497E+05	8.430E+05	7.742E+05	8.142E+05	3.997E+04	0.051
2025	8.003E+05	-1.984E+04	-2.48%	7.638E+05	8.586E+05	7.881E+05	8.268E+05	3.876E+04	0.048
2026	8.118E+05	-1.998E+04	-2.46%	7.764E+05	8.723E+05	8.004E+05	8.375E+05	3.713E+04	0.046

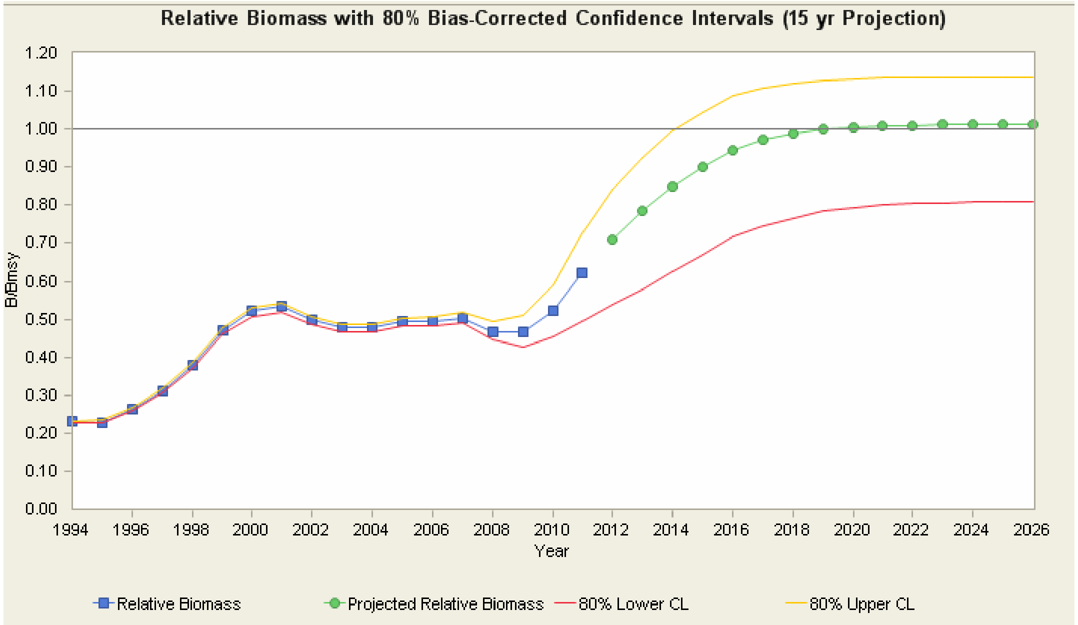


Fig. 7.11.2.5. Evolution of the relative biomass assuming reduction to $F_{0.1}$ in 2015.

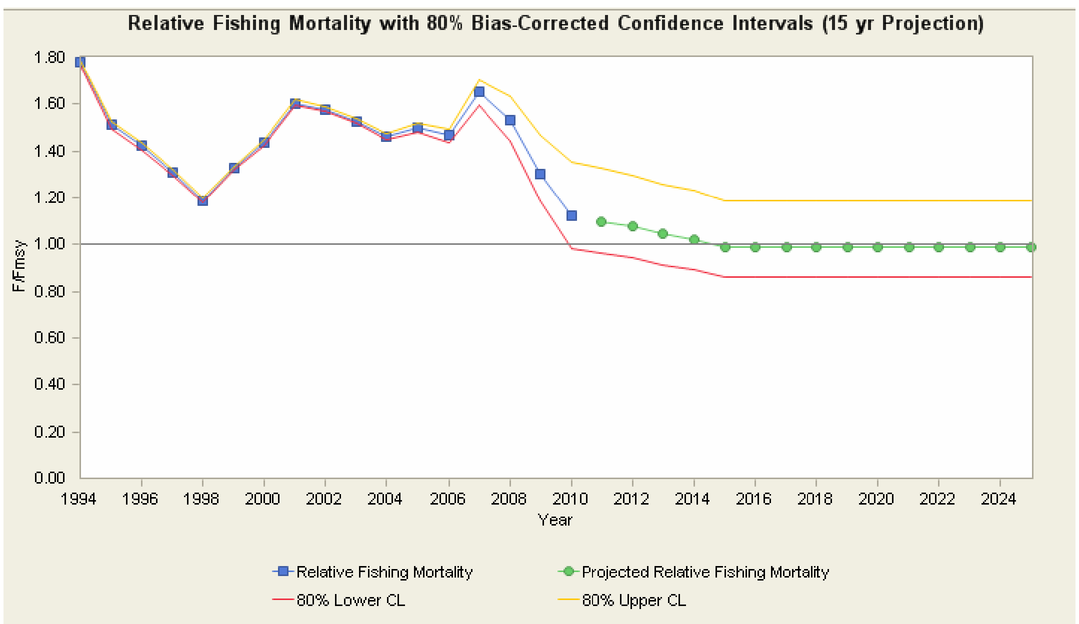


Fig. 7.11.2.6 Evolution of the relative fishing mortality assuming reduction to $F_{0.1}$ in 2015.

TABLE OF PROJECTED YIELDS

2011	1.950E+05	-1.758E+03	-0.90%	1.842E+05	1.998E+05	1.898E+05	1.979E+05	8.066E+03	0.041
2012	2.142E+05	-3.541E+03	-1.65%	1.955E+05	2.211E+05	2.058E+05	2.184E+05	1.263E+04	0.059
2013	2.267E+05	-5.038E+03	-2.22%	2.057E+05	2.328E+05	2.184E+05	2.312E+05	1.282E+04	0.057
2014	2.374E+05	-6.161E+03	-2.60%	2.206E+05	2.423E+05	2.317E+05	2.410E+05	9.343E+03	0.039
2015	2.423E+05	-6.758E+03	-2.79%	2.313E+05	2.472E+05	2.399E+05	2.448E+05	4.878E+03	0.020
2016	2.519E+05	-7.194E+03	-2.86%	2.479E+05	2.615E+05	2.515E+05	2.556E+05	4.118E+03	0.016

2017	2.576E+05	-7.353E+03	-2.85%	2.556E+05	2.709E+05	2.576E+05	2.638E+05	6.160E+03	0.024
2018	2.609E+05	-7.355E+03	-2.82%	2.603E+05	2.860E+05	2.613E+05	2.724E+05	1.109E+04	0.043
2019	2.628E+05	-7.288E+03	-2.77%	2.623E+05	2.891E+05	2.632E+05	2.768E+05	1.363E+04	0.052
2020	2.639E+05	-7.202E+03	-2.73%	2.633E+05	2.910E+05	2.642E+05	2.781E+05	1.387E+04	0.053
2021	2.645E+05	-7.119E+03	-2.69%	2.639E+05	2.921E+05	2.649E+05	2.789E+05	1.400E+04	0.053
2022	2.648E+05	-7.051E+03	-2.66%	2.644E+05	2.928E+05	2.654E+05	2.793E+05	1.386E+04	0.052
2023	2.650E+05	-6.997E+03	-2.64%	2.646E+05	2.932E+05	2.657E+05	2.795E+05	1.384E+04	0.052
2024	2.651E+05	-6.957E+03	-2.62%	2.648E+05	2.934E+05	2.659E+05	2.797E+05	1.376E+04	0.052
2025	2.652E+05	-6.928E+03	-2.61%	2.649E+05	2.936E+05	2.661E+05	2.798E+05	1.372E+04	0.052

TRAJECTORY OF ABSOLUTE BIOMASS (BOOTSTRAPPED)

Year	Point estimate	Estimated bias	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
1994	1.070E+05	-1.529E+03	-1.43%	1.032E+05	1.133E+05	1.060E+05	1.096E+05	3.616E+03	0.034
1995	1.063E+05	-1.641E+03	-1.54%	1.018E+05	1.130E+05	1.051E+05	1.090E+05	3.943E+03	0.037
1996	1.221E+05	-1.801E+03	-1.48%	1.168E+05	1.303E+05	1.206E+05	1.254E+05	4.731E+03	0.039
1997	1.442E+05	-1.920E+03	-1.33%	1.383E+05	1.542E+05	1.428E+05	1.486E+05	5.839E+03	0.041
1998	1.755E+05	-1.943E+03	-1.11%	1.687E+05	1.870E+05	1.738E+05	1.801E+05	6.324E+03	0.036
1999	2.189E+05	-1.889E+03	-0.86%	2.114E+05	2.314E+05	2.170E+05	2.238E+05	6.707E+03	0.031
2000	2.421E+05	-1.898E+03	-0.78%	2.345E+05	2.542E+05	2.400E+05	2.470E+05	6.924E+03	0.029
2001	2.475E+05	-1.971E+03	-0.80%	2.401E+05	2.595E+05	2.457E+05	2.523E+05	6.650E+03	0.027
2002	2.314E+05	-2.025E+03	-0.88%	2.245E+05	2.436E+05	2.299E+05	2.366E+05	6.709E+03	0.029
2003	2.227E+05	-2.022E+03	-0.91%	2.158E+05	2.348E+05	2.211E+05	2.277E+05	6.615E+03	0.030
2004	2.221E+05	-1.996E+03	-0.90%	2.151E+05	2.348E+05	2.204E+05	2.270E+05	6.546E+03	0.029
2005	2.286E+05	-1.954E+03	-0.85%	2.219E+05	2.420E+05	2.270E+05	2.345E+05	7.526E+03	0.033
2006	2.292E+05	-1.897E+03	-0.83%	2.223E+05	2.424E+05	2.274E+05	2.354E+05	8.061E+03	0.035
2007	2.332E+05	-1.797E+03	-0.77%	2.249E+05	2.462E+05	2.299E+05	2.400E+05	1.010E+04	0.043
2008	2.160E+05	-1.628E+03	-0.75%	2.039E+05	2.319E+05	2.102E+05	2.235E+05	1.330E+04	0.062
2009	2.164E+05	-1.444E+03	-0.67%	1.982E+05	2.436E+05	2.090E+05	2.297E+05	2.072E+04	0.096
2010	2.427E+05	-1.651E+03	-0.68%	2.125E+05	2.830E+05	2.297E+05	2.632E+05	3.348E+04	0.138
2011	2.887E+05	-3.360E+03	-1.16%	2.374E+05	3.443E+05	2.651E+05	3.168E+05	5.174E+04	0.179
2012	3.297E+05	-5.699E+03	-1.73%	2.667E+05	4.025E+05	3.010E+05	3.673E+05	6.631E+04	0.201
2013	3.639E+05	-8.347E+03	-2.29%	2.910E+05	4.442E+05	3.302E+05	4.063E+05	7.612E+04	0.209
2014	3.937E+05	-1.088E+04	-2.76%	3.147E+05	4.781E+05	3.581E+05	4.390E+05	8.084E+04	0.205
2015	4.175E+05	-1.292E+04	-3.10%	3.356E+05	5.018E+05	3.819E+05	4.637E+05	8.176E+04	0.196
2016	4.389E+05	-1.446E+04	-3.30%	3.514E+05	5.195E+05	4.029E+05	4.836E+05	8.076E+04	0.184
2017	4.519E+05	-1.534E+04	-3.39%	3.671E+05	5.317E+05	4.175E+05	4.973E+05	7.983E+04	0.177
2018	4.596E+05	-1.575E+04	-3.43%	3.777E+05	5.372E+05	4.261E+05	5.038E+05	7.766E+04	0.169
2019	4.639E+05	-1.590E+04	-3.43%	3.846E+05	5.447E+05	4.330E+05	5.111E+05	7.813E+04	0.168
2020	4.664E+05	-1.590E+04	-3.41%	3.884E+05	5.459E+05	4.364E+05	5.135E+05	7.709E+04	0.165
2021	4.679E+05	-1.585E+04	-3.39%	3.907E+05	5.470E+05	4.380E+05	5.150E+05	7.704E+04	0.165
2022	4.687E+05	-1.579E+04	-3.37%	3.922E+05	5.483E+05	4.398E+05	5.163E+05	7.650E+04	0.163
2023	4.691E+05	-1.573E+04	-3.35%	3.931E+05	5.486E+05	4.401E+05	5.166E+05	7.651E+04	0.163
2024	4.694E+05	-1.568E+04	-3.34%	3.936E+05	5.487E+05	4.403E+05	5.167E+05	7.642E+04	0.163
2025	4.695E+05	-1.564E+04	-3.33%	3.937E+05	5.488E+05	4.405E+05	5.167E+05	7.625E+04	0.162
2026	4.696E+05	-1.561E+04	-3.32%	3.937E+05	5.488E+05	4.406E+05	5.168E+05	7.618E+04	0.162

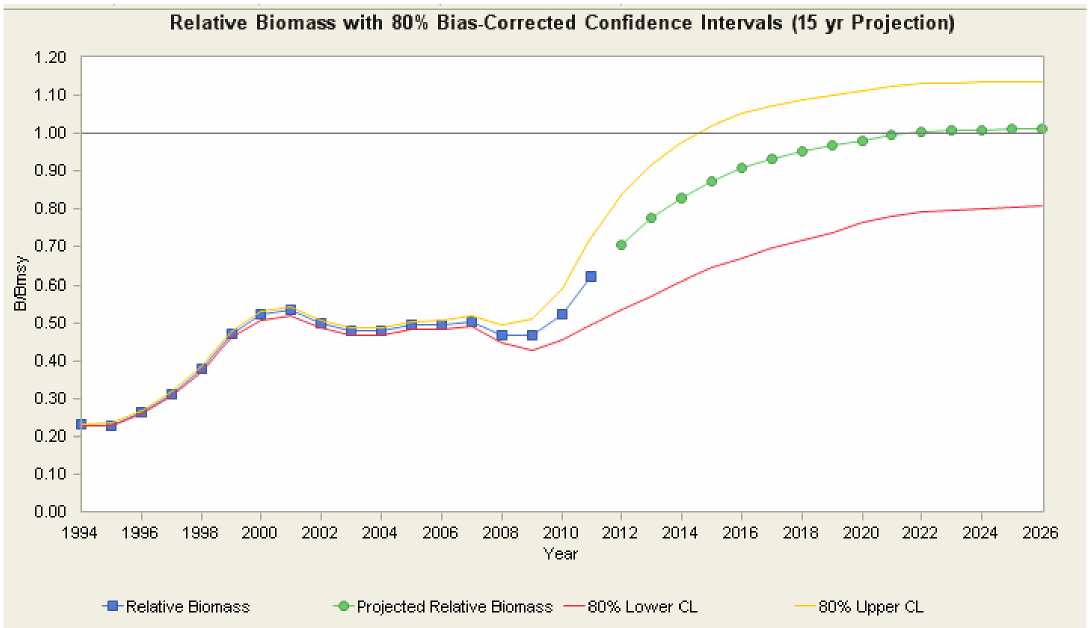


Fig. 7.11.2.7 Evolution of the relative biomass assuming reduction to $F_{0.1}$ in 2020.

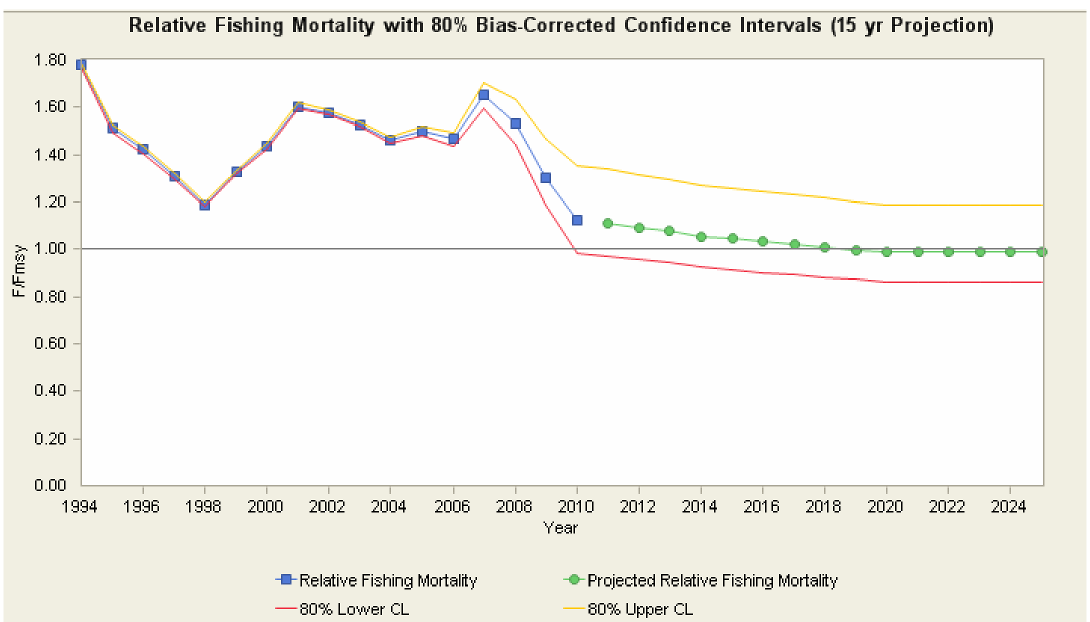


Fig. 7.11.2.8 Evolution of the relative fishing mortality assuming reduction to $F_{0.1}$ in 2020.

TABLE OF PROJECTED YIELDS

2011	1.964E+05	-1.781E+03	-0.91%	1.855E+05	2.013E+05	1.913E+05	1.994E+05	8.096E+03	0.041
2012	2.157E+05	-3.597E+03	-1.67%	1.964E+05	2.229E+05	2.068E+05	2.200E+05	1.319E+04	0.061
2013	2.300E+05	-5.183E+03	-2.25%	2.075E+05	2.369E+05	2.211E+05	2.350E+05	1.389E+04	0.060
2014	2.389E+05	-6.336E+03	-2.65%	2.173E+05	2.446E+05	2.321E+05	2.434E+05	1.131E+04	0.047
2015	2.470E+05	-7.126E+03	-2.89%	2.317E+05	2.524E+05	2.433E+05	2.506E+05	7.338E+03	0.030

2016	2.521E+05	-7.554E+03	-3.00%	2.426E+05	2.582E+05	2.499E+05	2.549E+05	5.000E+03	0.020
2017	2.553E+05	-7.720E+03	-3.02%	2.499E+05	2.645E+05	2.543E+05	2.584E+05	4.163E+03	0.016
2018	2.573E+05	-7.717E+03	-3.00%	2.541E+05	2.708E+05	2.572E+05	2.622E+05	5.016E+03	0.019
2019	2.585E+05	-7.616E+03	-2.95%	2.569E+05	2.759E+05	2.586E+05	2.674E+05	8.742E+03	0.034
2020	2.592E+05	-7.463E+03	-2.88%	2.584E+05	2.762E+05	2.595E+05	2.713E+05	1.182E+04	0.046
2021	2.618E+05	-7.367E+03	-2.81%	2.613E+05	2.888E+05	2.622E+05	2.765E+05	1.430E+04	0.055
2022	2.633E+05	-7.263E+03	-2.76%	2.628E+05	2.908E+05	2.637E+05	2.779E+05	1.415E+04	0.054
2023	2.642E+05	-7.167E+03	-2.71%	2.636E+05	2.920E+05	2.645E+05	2.787E+05	1.425E+04	0.054
2024	2.646E+05	-7.087E+03	-2.68%	2.642E+05	2.927E+05	2.652E+05	2.792E+05	1.403E+04	0.053
2025	2.649E+05	-7.025E+03	-2.65%	2.646E+05	2.931E+05	2.656E+05	2.795E+05	1.391E+04	0.052

TRAJECTORY OF ABSOLUTE BIOMASS (BOOTSTRAPPED)

Year	Point estimate	Estimated bias	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
1994	1.070E+05	-1.529E+03	-1.43%	1.032E+05	1.133E+05	1.060E+05	1.096E+05	3.616E+03	0.034
1995	1.063E+05	-1.641E+03	-1.54%	1.018E+05	1.130E+05	1.051E+05	1.090E+05	3.943E+03	0.037
1996	1.221E+05	-1.801E+03	-1.48%	1.168E+05	1.303E+05	1.206E+05	1.254E+05	4.731E+03	0.039
1997	1.442E+05	-1.920E+03	-1.33%	1.383E+05	1.542E+05	1.428E+05	1.486E+05	5.839E+03	0.041
1998	1.755E+05	-1.943E+03	-1.11%	1.687E+05	1.870E+05	1.738E+05	1.801E+05	6.324E+03	0.036
1999	2.189E+05	-1.889E+03	-0.86%	2.114E+05	2.314E+05	2.170E+05	2.238E+05	6.707E+03	0.031
2000	2.421E+05	-1.898E+03	-0.78%	2.345E+05	2.542E+05	2.400E+05	2.470E+05	6.924E+03	0.029
2001	2.475E+05	-1.971E+03	-0.80%	2.401E+05	2.595E+05	2.457E+05	2.523E+05	6.650E+03	0.027
2002	2.314E+05	-2.025E+03	-0.88%	2.245E+05	2.436E+05	2.299E+05	2.366E+05	6.709E+03	0.029
2003	2.227E+05	-2.022E+03	-0.91%	2.158E+05	2.348E+05	2.211E+05	2.277E+05	6.615E+03	0.030
2004	2.221E+05	-1.996E+03	-0.90%	2.151E+05	2.348E+05	2.204E+05	2.270E+05	6.546E+03	0.029
2005	2.286E+05	-1.954E+03	-0.85%	2.219E+05	2.420E+05	2.270E+05	2.345E+05	7.526E+03	0.033
2006	2.292E+05	-1.897E+03	-0.83%	2.223E+05	2.424E+05	2.274E+05	2.354E+05	8.061E+03	0.035
2007	2.332E+05	-1.797E+03	-0.77%	2.249E+05	2.462E+05	2.299E+05	2.400E+05	1.010E+04	0.043
2008	2.160E+05	-1.628E+03	-0.75%	2.039E+05	2.319E+05	2.102E+05	2.235E+05	1.330E+04	0.062
2009	2.164E+05	-1.444E+03	-0.67%	1.982E+05	2.436E+05	2.090E+05	2.297E+05	2.072E+04	0.096
2010	2.427E+05	-1.651E+03	-0.68%	2.125E+05	2.830E+05	2.297E+05	2.632E+05	3.348E+04	0.138
2011	2.887E+05	-3.360E+03	-1.16%	2.374E+05	3.443E+05	2.651E+05	3.168E+05	5.174E+04	0.179
2012	3.279E+05	-5.665E+03	-1.73%	2.650E+05	4.008E+05	2.993E+05	3.656E+05	6.629E+04	0.202
2013	3.599E+05	-8.231E+03	-2.29%	2.870E+05	4.403E+05	3.261E+05	4.024E+05	7.630E+04	0.212
2014	3.850E+05	-1.060E+04	-2.75%	3.060E+05	4.699E+05	3.493E+05	4.304E+05	8.111E+04	0.211
2015	4.056E+05	-1.254E+04	-3.09%	3.243E+05	4.905E+05	3.698E+05	4.519E+05	8.205E+04	0.202
2016	4.208E+05	-1.391E+04	-3.31%	3.357E+05	5.037E+05	3.848E+05	4.672E+05	8.241E+04	0.196
2017	4.323E+05	-1.480E+04	-3.42%	3.472E+05	5.132E+05	3.964E+05	4.780E+05	8.163E+04	0.189
2018	4.413E+05	-1.534E+04	-3.48%	3.571E+05	5.220E+05	4.066E+05	4.876E+05	8.096E+04	0.183
2019	4.489E+05	-1.566E+04	-3.49%	3.614E+05	5.269E+05	4.127E+05	4.925E+05	7.975E+04	0.178
2020	4.556E+05	-1.584E+04	-3.48%	3.736E+05	5.338E+05	4.223E+05	4.998E+05	7.747E+04	0.170
2021	4.617E+05	-1.595E+04	-3.45%	3.809E+05	5.411E+05	4.298E+05	5.088E+05	7.895E+04	0.171
2022	4.651E+05	-1.595E+04	-3.43%	3.868E+05	5.448E+05	4.351E+05	5.123E+05	7.716E+04	0.166
2023	4.671E+05	-1.589E+04	-3.40%	3.898E+05	5.464E+05	4.372E+05	5.143E+05	7.718E+04	0.165
2024	4.682E+05	-1.583E+04	-3.38%	3.917E+05	5.480E+05	4.394E+05	5.159E+05	7.653E+04	0.163
2025	4.689E+05	-1.576E+04	-3.36%	3.921E+05	5.481E+05	4.395E+05	5.161E+05	7.656E+04	0.163
2026	4.692E+05	-1.570E+04	-3.35%	3.934E+05	5.486E+05	4.401E+05	5.166E+05	7.650E+04	0.163

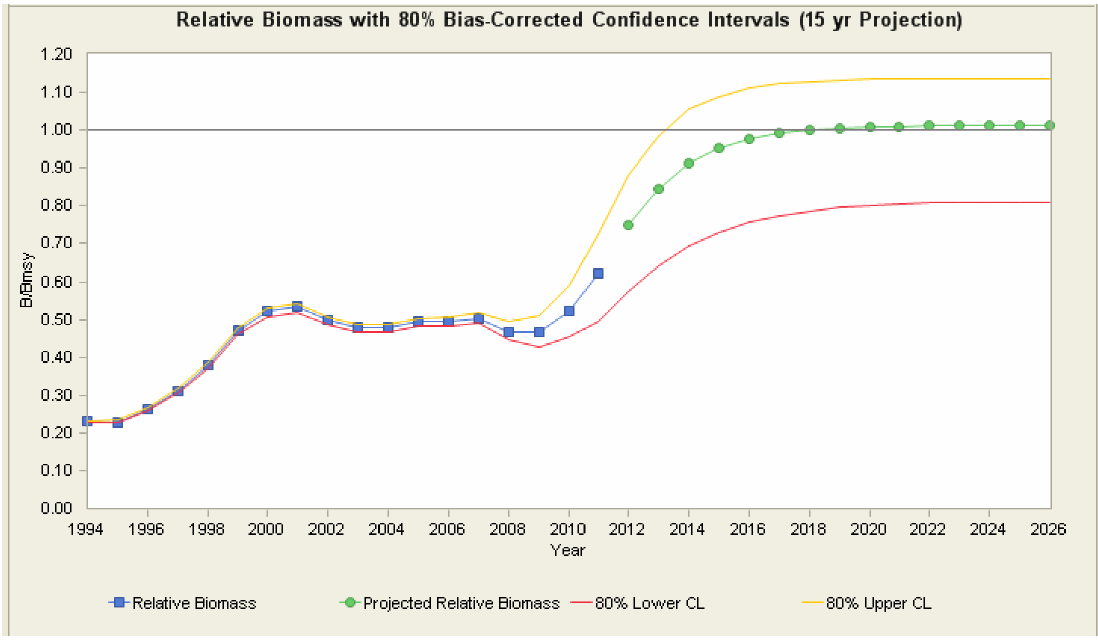


Fig. 7.11.2.9 Evolution of the relative biomass assuming adopting F0.1 since 2012.

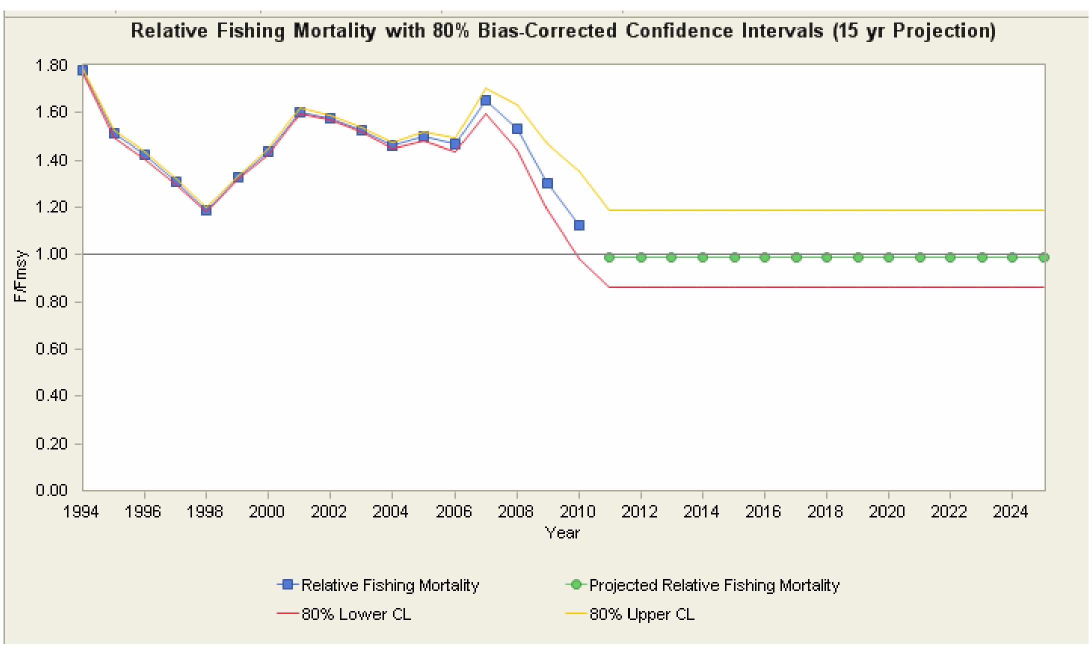


Fig. 7.11.2.10 Evolution of the relative fishing mortality assuming adopting F0.1 since 2012.

TABLE OF PROJECTED YIELDS

2011	1.803E+05	-1.524E+03	-0.85%	1.709E+05	1.840E+05	1.759E+05	1.825E+05	6.639E+03	0.037
2012	2.097E+05	-3.225E+03	-1.54%	1.956E+05	2.139E+05	2.039E+05	2.126E+05	8.731E+03	0.042
2013	2.309E+05	-4.792E+03	-2.08%	2.179E+05	2.347E+05	2.266E+05	2.333E+05	6.751E+03	0.029
2014	2.448E+05	-5.915E+03	-2.42%	2.391E+05	2.498E+05	2.434E+05	2.471E+05	3.662E+03	0.015
2015	2.534E+05	-6.579E+03	-2.60%	2.508E+05	2.641E+05	2.532E+05	2.575E+05	4.268E+03	0.017

2016	2.585E+05	-6.909E+03	-2.67%	2.573E+05	2.725E+05	2.586E+05	2.671E+05	8.462E+03	0.033
2017	2.614E+05	-7.040E+03	-2.69%	2.608E+05	2.859E+05	2.618E+05	2.727E+05	1.092E+04	0.042
2018	2.631E+05	-7.066E+03	-2.69%	2.625E+05	2.890E+05	2.635E+05	2.767E+05	1.324E+04	0.050
2019	2.640E+05	-7.047E+03	-2.67%	2.635E+05	2.909E+05	2.644E+05	2.780E+05	1.365E+04	0.052
2020	2.646E+05	-7.013E+03	-2.65%	2.640E+05	2.921E+05	2.650E+05	2.788E+05	1.381E+04	0.052
2021	2.649E+05	-6.977E+03	-2.63%	2.645E+05	2.927E+05	2.655E+05	2.793E+05	1.378E+04	0.052
2022	2.650E+05	-6.947E+03	-2.62%	2.647E+05	2.932E+05	2.658E+05	2.795E+05	1.378E+04	0.052
2023	2.651E+05	-6.923E+03	-2.61%	2.648E+05	2.934E+05	2.659E+05	2.797E+05	1.380E+04	0.052
2024	2.652E+05	-6.904E+03	-2.60%	2.649E+05	2.935E+05	2.661E+05	2.798E+05	1.369E+04	0.052
2025	2.652E+05	-6.891E+03	-2.60%	2.649E+05	2.936E+05	2.661E+05	2.798E+05	1.369E+04	0.052

TRAJECTORY OF ABSOLUTE BIOMASS (BOOTSTRAPPED)

Year	Point estimate	Estimated bias	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	relative IQ range
1994	1.070E+05	-1.529E+03	-1.43%	1.032E+05	1.133E+05	1.060E+05	1.096E+05	3.616E+03	0.034
1995	1.063E+05	-1.641E+03	-1.54%	1.018E+05	1.130E+05	1.051E+05	1.090E+05	3.943E+03	0.037
1996	1.221E+05	-1.801E+03	-1.48%	1.168E+05	1.303E+05	1.206E+05	1.254E+05	4.731E+03	0.039
1997	1.442E+05	-1.920E+03	-1.33%	1.383E+05	1.542E+05	1.428E+05	1.486E+05	5.839E+03	0.041
1998	1.755E+05	-1.943E+03	-1.11%	1.687E+05	1.870E+05	1.738E+05	1.801E+05	6.324E+03	0.036
1999	2.189E+05	-1.889E+03	-0.86%	2.114E+05	2.314E+05	2.170E+05	2.238E+05	6.707E+03	0.031
2000	2.421E+05	-1.898E+03	-0.78%	2.345E+05	2.542E+05	2.400E+05	2.470E+05	6.924E+03	0.029
2001	2.475E+05	-1.971E+03	-0.80%	2.401E+05	2.595E+05	2.457E+05	2.523E+05	6.650E+03	0.027
2002	2.314E+05	-2.025E+03	-0.88%	2.245E+05	2.436E+05	2.299E+05	2.366E+05	6.709E+03	0.029
2003	2.227E+05	-2.022E+03	-0.91%	2.158E+05	2.348E+05	2.211E+05	2.277E+05	6.615E+03	0.030
2004	2.221E+05	-1.996E+03	-0.90%	2.151E+05	2.348E+05	2.204E+05	2.270E+05	6.546E+03	0.029
2005	2.286E+05	-1.954E+03	-0.85%	2.219E+05	2.420E+05	2.270E+05	2.345E+05	7.526E+03	0.033
2006	2.292E+05	-1.897E+03	-0.83%	2.223E+05	2.424E+05	2.274E+05	2.354E+05	8.061E+03	0.035
2007	2.332E+05	-1.797E+03	-0.77%	2.249E+05	2.462E+05	2.299E+05	2.400E+05	1.010E+04	0.043
2008	2.160E+05	-1.628E+03	-0.75%	2.039E+05	2.319E+05	2.102E+05	2.235E+05	1.330E+04	0.062
2009	2.164E+05	-1.444E+03	-0.67%	1.982E+05	2.436E+05	2.090E+05	2.297E+05	2.072E+04	0.096
2010	2.427E+05	-1.651E+03	-0.68%	2.125E+05	2.830E+05	2.297E+05	2.632E+05	3.348E+04	0.138
2011	2.887E+05	-3.360E+03	-1.16%	2.374E+05	3.443E+05	2.651E+05	3.168E+05	5.174E+04	0.179
2012	3.476E+05	-6.039E+03	-1.74%	2.842E+05	4.199E+05	3.188E+05	3.853E+05	6.652E+04	0.191
2013	3.924E+05	-9.161E+03	-2.33%	3.195E+05	4.720E+05	3.587E+05	4.335E+05	7.479E+04	0.191
2014	4.230E+05	-1.182E+04	-2.79%	3.451E+05	5.042E+05	3.893E+05	4.674E+05	7.813E+04	0.185
2015	4.423E+05	-1.365E+04	-3.09%	3.613E+05	5.216E+05	4.079E+05	4.863E+05	7.836E+04	0.177
2016	4.539E+05	-1.474E+04	-3.25%	3.691E+05	5.314E+05	4.196E+05	4.980E+05	7.836E+04	0.173
2017	4.607E+05	-1.531E+04	-3.32%	3.803E+05	5.377E+05	4.279E+05	5.045E+05	7.656E+04	0.166
2018	4.646E+05	-1.558E+04	-3.35%	3.850E+05	5.433E+05	4.333E+05	5.113E+05	7.804E+04	0.168
2019	4.668E+05	-1.568E+04	-3.36%	3.895E+05	5.460E+05	4.367E+05	5.137E+05	7.701E+04	0.165
2020	4.681E+05	-1.570E+04	-3.35%	3.914E+05	5.471E+05	4.384E+05	5.151E+05	7.677E+04	0.164
2021	4.688E+05	-1.568E+04	-3.35%	3.926E+05	5.483E+05	4.399E+05	5.164E+05	7.652E+04	0.163
2022	4.692E+05	-1.566E+04	-3.34%	3.923E+05	5.483E+05	4.400E+05	5.164E+05	7.639E+04	0.163
2023	4.694E+05	-1.563E+04	-3.33%	3.936E+05	5.487E+05	4.403E+05	5.167E+05	7.637E+04	0.163
2024	4.695E+05	-1.561E+04	-3.32%	3.937E+05	5.488E+05	4.405E+05	5.167E+05	7.621E+04	0.162
2025	4.696E+05	-1.559E+04	-3.32%	3.937E+05	5.488E+05	4.407E+05	5.168E+05	7.616E+04	0.162
2026	4.696E+05	-1.557E+04	-3.32%	3.937E+05	5.489E+05	4.407E+05	5.168E+05	7.611E+04	0.162

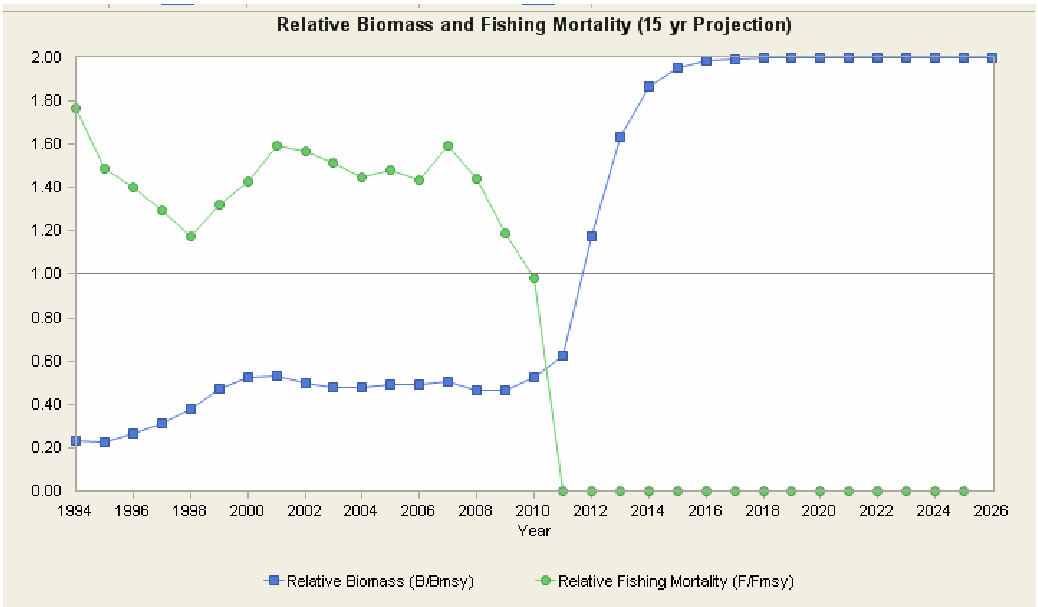


Fig. 7.11.2.11 Evolution of the relative biomass assuming the fishing mortality F=0.

TRAJECTORY OF ABSOLUTE BIOMASS (BOOTSTRAPPED)

Year	Point estimate	Estimated bias	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
1994	1.070E+05	-1.529E+03	-1.43%	1.032E+05	1.133E+05	1.060E+05	1.096E+05	3.616E+03	0.034
1995	1.063E+05	-1.641E+03	-1.54%	1.018E+05	1.130E+05	1.051E+05	1.090E+05	3.943E+03	0.037
1996	1.221E+05	-1.801E+03	-1.48%	1.168E+05	1.303E+05	1.206E+05	1.254E+05	4.731E+03	0.039
1997	1.442E+05	-1.920E+03	-1.33%	1.383E+05	1.542E+05	1.428E+05	1.486E+05	5.839E+03	0.041
1998	1.755E+05	-1.943E+03	-1.11%	1.687E+05	1.870E+05	1.738E+05	1.801E+05	6.324E+03	0.036
1999	2.189E+05	-1.889E+03	-0.86%	2.114E+05	2.314E+05	2.170E+05	2.238E+05	6.707E+03	0.031
2000	2.421E+05	-1.898E+03	-0.78%	2.345E+05	2.542E+05	2.400E+05	2.470E+05	6.924E+03	0.029
2001	2.475E+05	-1.971E+03	-0.80%	2.401E+05	2.595E+05	2.457E+05	2.523E+05	6.650E+03	0.027
2002	2.314E+05	-2.025E+03	-0.88%	2.245E+05	2.436E+05	2.299E+05	2.366E+05	6.709E+03	0.029
2003	2.227E+05	-2.022E+03	-0.91%	2.158E+05	2.348E+05	2.211E+05	2.277E+05	6.615E+03	0.030
2004	2.221E+05	-1.996E+03	-0.90%	2.151E+05	2.348E+05	2.204E+05	2.270E+05	6.546E+03	0.029
2005	2.286E+05	-1.954E+03	-0.85%	2.219E+05	2.420E+05	2.270E+05	2.345E+05	7.526E+03	0.033
2006	2.292E+05	-1.897E+03	-0.83%	2.223E+05	2.424E+05	2.274E+05	2.354E+05	8.061E+03	0.035
2007	2.332E+05	-1.797E+03	-0.77%	2.249E+05	2.462E+05	2.299E+05	2.400E+05	1.010E+04	0.043
2008	2.160E+05	-1.628E+03	-0.75%	2.039E+05	2.319E+05	2.102E+05	2.235E+05	1.330E+04	0.062
2009	2.164E+05	-1.444E+03	-0.67%	1.982E+05	2.436E+05	2.090E+05	2.297E+05	2.072E+04	0.096
2010	2.427E+05	-1.651E+03	-0.68%	2.125E+05	2.830E+05	2.297E+05	2.632E+05	3.348E+04	0.138
2011	2.887E+05	-3.360E+03	-1.16%	2.374E+05	3.443E+05	2.651E+05	3.168E+05	5.174E+04	0.179
2012	5.441E+05	-8.659E+03	-1.59%	4.839E+05	6.066E+05	5.189E+05	5.778E+05	5.887E+04	0.108
2013	7.576E+05	-1.555E+04	-2.05%	7.148E+05	8.059E+05	7.407E+05	7.829E+05	4.222E+04	0.056
2014	8.659E+05	-1.936E+04	-2.24%	8.357E+05	9.221E+05	8.565E+05	8.876E+05	3.110E+04	0.036
2015	9.072E+05	-2.083E+04	-2.30%	8.862E+05	9.858E+05	9.035E+05	9.429E+05	3.935E+04	0.043
2016	9.212E+05	-2.133E+04	-2.32%	8.966E+05	9.955E+05	9.177E+05	9.570E+05	3.927E+04	0.043
2017	9.258E+05	-2.149E+04	-2.32%	8.958E+05	9.954E+05	9.215E+05	9.586E+05	3.702E+04	0.040
2018	9.272E+05	-2.154E+04	-2.32%	8.946E+05	9.968E+05	9.221E+05	9.595E+05	3.739E+04	0.040
2019	9.277E+05	-2.155E+04	-2.32%	8.959E+05	9.975E+05	9.229E+05	9.607E+05	3.781E+04	0.041
2020	9.279E+05	-2.155E+04	-2.32%	8.951E+05	9.977E+05	9.227E+05	9.604E+05	3.772E+04	0.041
2021	9.279E+05	-2.155E+04	-2.32%	8.951E+05	9.978E+05	9.228E+05	9.605E+05	3.775E+04	0.041
2022	9.279E+05	-2.155E+04	-2.32%	8.951E+05	9.978E+05	9.228E+05	9.605E+05	3.776E+04	0.041
2023	9.279E+05	-2.155E+04	-2.32%	8.951E+05	9.978E+05	9.228E+05	9.605E+05	3.776E+04	0.041
2024	9.279E+05	-2.155E+04	-2.32%	8.951E+05	9.978E+05	9.228E+05	9.605E+05	3.776E+04	0.041
2025	9.279E+05	-2.155E+04	-2.32%	8.951E+05	9.978E+05	9.228E+05	9.605E+05	3.776E+04	0.041
2026	9.279E+05	-2.155E+04	-2.32%	8.951E+05	9.978E+05	9.228E+05	9.605E+05	3.776E+04	0.041

7.11.3 Results

The results suggest the need of a relatively modest reduction of fishing mortality to drive F to F_{MSY} (about 12 %). At such rate, catch is expected to increase very slightly in a long term (of about 2%), while the total biomass should grow up to 15% (the B_{MSY} level).

7.12 Pink shrimp (*Parapenaeus longirostris*) in GSA 9

7.12.1 Short term prediction 2011-2013

7.12.1.1 Method and justification

Short term predictions were implemented in R (www.r-project.org) using the FLR libraries and based on the results of Extended Survivors Analysis (XSA) carried out on 2006-2010 catch data collected under DCF.

7.12.1.2 Input parameters

The following data have been used to derive the input data for the short term projection of the pink shrimp stock in GSA9:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4+
2006-2010	Prop. Matures	0.3	0.8	1.0	1.0	1.0

PERIOD	Age	0	1	2	3	4+
2006-2010	M	1.20	0.78	0.76	0.65	0.50

F vector

F	0	1	2	3	4+
2006	0.01	0.65	1.67	1.05	1.05
2007	0.02	0.52	1.03	0.78	0.78
2008	0.04	0.57	1.12	0.95	0.95
2009	0.08	0.48	0.44	0.76	0.76
2010	0.16	0.31	0.38	0.24	0.24

Weight-at-age in the stock

Mean weight in stock (kg)	0	1	2	3	4+
2006	0.001	0.009	0.018	0.024	0.030
2007	0.001	0.009	0.017	0.023	0.030
2008	0.001	0.009	0.018	0.024	0.030
2009	0.001	0.009	0.017	0.023	0.027
2010	0.004	0.009	0.018	0.014	0.029

Weight-at-age in the catch

Mean weight in catch (kg)	0	1	2	3	4+
2006	0.001	0.009	0.018	0.024	0.030
2007	0.001	0.009	0.017	0.023	0.030
2008	0.001	0.009	0.018	0.024	0.030
2009	0.001	0.009	0.017	0.023	0.027
2010	0.004	0.009	0.018	0.014	0.029

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2	3	4+
2006	550	15457	12364	2063	467
2007	1169	10825	5211	792	332
2008	3402	11852	5072	912	951
2009	19465	12113	2617	667	1129
2010	20765	25752	3005	527	738

Number at age in the stock

Stock numbers at age (in thousands)	0	1	2	3	4+
2006	107400	47848	21500	4393	925
2007	111145	39177	11468	2027	802
2008	133732	40179	10630	2062	2011
2009	414866	47134	10394	1739	2780
2010	231212	140815	13405	3360	4563
2011	234091*	72482	47344	4598	1380

* Geometric mean of the last three years (2008-2010).

Maturity was estimated as the mean of the last 3 years. M was calculated using the ProBiom method.

7.12.1.3 Results

A short term projection (Table 7.12.1.3.1), assuming an F_{stq} of 0.51 in 2011 and a recruitment of 234 million individuals, shows that:

- Fishing at the F_{stq} from 2011 to 2012 generates a decrease in catch of 28% and a slight increase in SSB of 2% between 2012 and 2013.
- Fishing at F_{MSY} (0.60) for the same time frame generates a decrease in the catches of 16% between 2010 and 2012 and a slight decrease of spawning stock biomass of 4% from 2012 to 2013.

STECF EWG 11-20 advice considers the stock being harvested sustainably, as F_{1-3} was estimated to range among 1.3 and 0.3 in the period 2006-2010. STECF EWG 11-20 recommends that in 2011 fishing mortality should not exceed the value of F_{MSY} = 0.60, which corresponds to a catch of about 330 tons.

Outlook until 2013

Table 7.12.1.3.1 - Short term forecast in different F scenarios computed for pink shrimp in GSA 9.

Basis: F(2010) = mean(F_{bar} 2006–2010); R(2011) = GM(2006–2010) = 234 (millions); F (2010) = 0.51; SSB(2012) = 780 t; Catch (2011) = 282 t. Weights in tons.

Rationale	F scenario	F factor	Catch 2012	Catch 2013	SSB 2013	Change SSB 2012 -2013 (%)	Change Catch 2010 -2012 (%)
Zero catch	0.00	0.00	0	0	1130	39.6	-100.0
High long term yield (FMSY)	0.62	1.20	339	327	748	-3.7	-16.4
Status quo	0.51	1.00	292	297	800	2.3	-28.1
Different scenarios	0.10	0.20	68	88	1051	30.7	-83.1
	0.20	0.40	131	159	980	22.6	-67.6
	0.31	0.60	189	216	914	15.2	-53.3
	0.41	0.80	242	261	855	8.5	-40.2
	0.61	1.20	337	325	750	-3.4	-16.9
	0.71	1.40	379	348	704	-8.6	-6.5
	0.81	1.60	418	365	662	-13.3	3.0
	0.92	1.80	454	378	624	-17.7	11.9
	1.02	2.00	487	387	588	-21.7	20.1
	0.00	0.00	0	0	1130	39.6	-100.0
	0.62	1.20	339	327	748	-3.7	-16.4
	0.51	1.00	292	297	800	2.3	-28.1
	0.10	0.20	68	88	1051	30.7	-83.1
	0.20	0.40	131	159	980	22.6	-67.6
	0.31	0.60	189	216	914	15.2	-53.3
	0.41	0.80	242	261	855	8.5	-40.2
	0.61	1.20	337	325	750	-3.4	-16.9
	0.71	1.40	379	348	704	-8.6	-6.5
	0.81	1.60	418	365	662	-13.3	3.0

7.12.2 Medium term prediction

7.12.2.1 Method and justification

Medium term prediction from 2011 to 2020 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of stock assessment obtained using XSA. Medium term projections (10 years) were run assuming

5) a constant $F = F_{MSY}$ since 2011;
6) a constant decrease of F by 10% per year;
7) a progressive increasing trend of F toward F_{MSY} in 5 years (2015);
8) a progressive increasing trend of F toward F_{MSY} in 10 years (2020).

The stock-recruitment relationship used geometric mean recruitment over the observed SSB range from 2008 to 2010. Runs were made with 500 simulations per run using a deterministic process, due to the low number of observations.

7.12.2.2 Input parameters

The maturity ogive, the natural mortality, the numbers of individuals and weight-at-age for the stock and for the catch were the same used in the short term forecast.

7.12.2.3 Results

In figure 7.12.2.3.1, the 25th, 50th, and 75th percentile are showed for the SSB, recruitment and catches in t from 2011 to 2020, considering a constant $F = F_{MSY}$ since 2011.
In figure 7.12.2.3.2, the 25th, 50th, and 75th percentile are showed for the SSB, recruitment and catches in t from 2011 to 2020, considering a constant reduction of the F_{stq} of around 10% each year.
In figure 7.12.2.3.3, the 25th, 50th, and 75th percentile are showed for the SSB, recruitment and catches in t from 2011 to 2020, considering an increase of the F_{stq} from 2011 to 2015, to reach F_{MSY} in 2015, and then a constant $F = F_{MSY}$ until 2020.
In figure 7.12.2.3.4, the 25th, 50th, and 75th percentile are showed for the SSB, recruitment and catches in t from 2011 to 2020, considering an increase of the F_{stq} from 2011 to reach $F = F_{MSY}$ in 2020.

Landing data of pink shrimp from 2006 to 2010 in the GSA09 are reported in Table 7.12.2.3.1. The landings of this species are characterised by huge fluctuations; anyway, an increasing pattern was observed in the data since 2007.

The first scenario ($F = F_{MSY}$ since 2011) shows a constant behaviour at high values of both SSB and Yield, after an initial decrease from the very high observed in 2010. The same results are obtained by increasing F until reaching F MSY in 2015 and in 2020, and then fixing it constant (third and fourth scenario).

In the second of the four scenarios which have been fitted, we observe a decrease of the Yield, and an increase of the SSB.

Table 7.12.2.3.1. Landings of pink shrimp in the GSA 9 (in tons).

year	2006	2007	2008	2009	2010
DCF landings	462	217	254	298	463

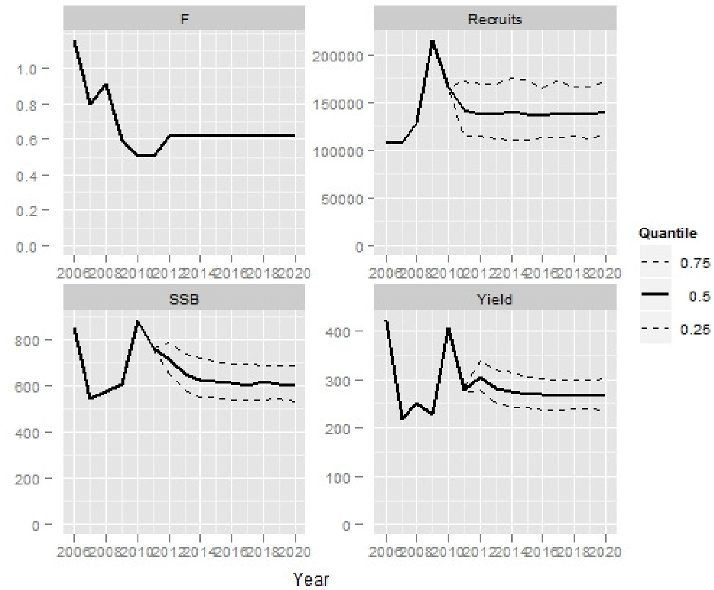


Fig. 7.12.2.3.1. Output of the medium term forecast computed for the pink shrimp in the GSA 9 reaching the F_{MSY} in 2011.

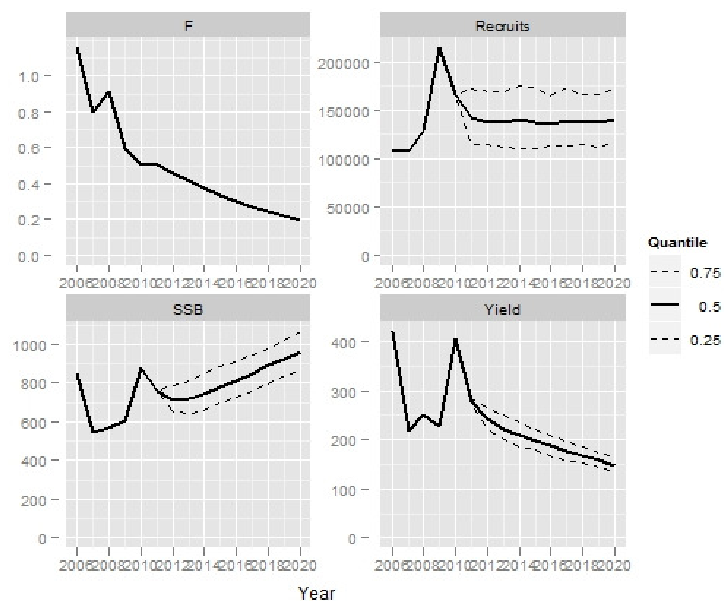


Fig. 7.12.2.3.2. Output of the medium term forecast computed for the pink shrimp in the GSA 09 considering an increase of F by 10% per year.

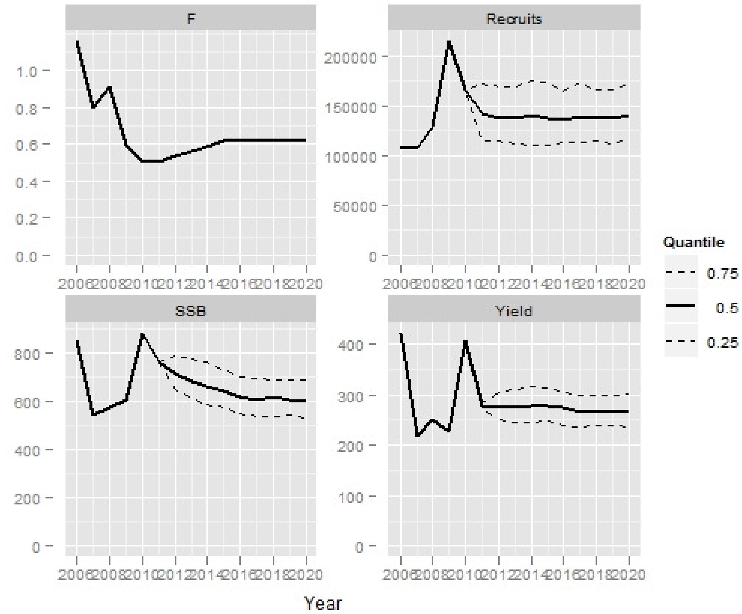


Fig. 7.12.2.3.3. Output of the medium term forecast computed for the pink shrimp in the GSA 09 reaching the F_{MSY} in 2015.

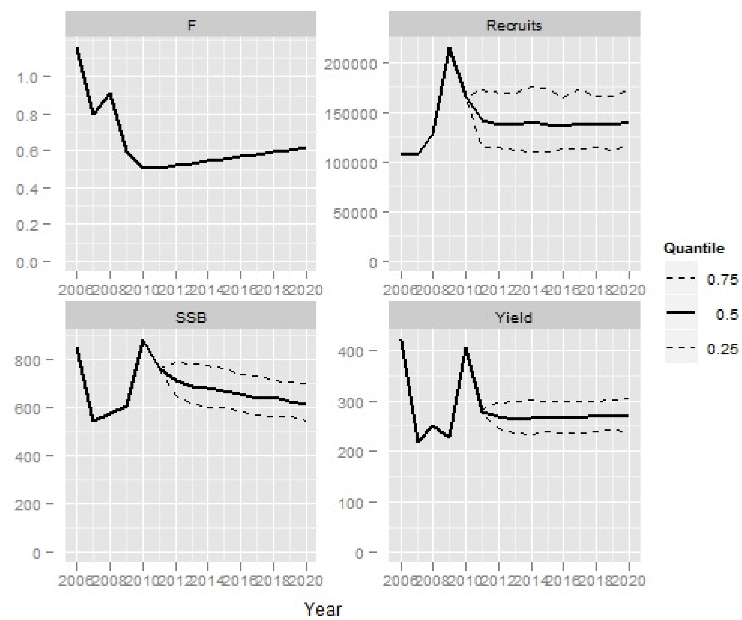


Fig. 7.12.2.3.4. Output of the medium term forecast computed for the pink shrimp in the GSA 09 reaching the F_{MSY} in 2020.

7.13 Blue and red shrimp (*Aristeus antennatus*) in GSA 9

7.13.1 Short term prediction 2011-2013

7.13.1.1 Method and justification

Short term predictions for 2012 and 2013 were implemented in R (www.r-project.org) using the FLR libraries and based on the results of Length Cohort Analysis (LCA) carried out on 2008-2010 of catch data collected under DCF.

7.13.1.2 Input parameters

The following data have been used to derive the input data for the short term projection of the blue and red shrimp stock in GSA9:

Maturity and M vectors

PERIOD	Age	1	2	3	4	5	6	7	8
2010	Prop. Matures	0.8	1.0	1.0	1.0	1.0	1.0	1.0	1.0

PERIOD	Age	1	2	3	4	5	6	7	8
2010	M	0.76	0.50	0.41	0.36	0.34	0.32	0.31	0.30

F vector

PERIOD	Age	1	2	3	4	5	6	7	8
2008	F	0.141	0.250	0.321	0.480	0.573	0.906	1.015	0.499
2009		0.035	0.142	0.430	0.830	0.940	0.993	1.674	1.708
2010		0.030	0.166	0.573	0.952	0.983	0.772	0.538	0.500
Mean 2008-2010 rescale		0.060	0.163	0.387	0.661	0.729	0.780	0.943	0.791

F_{stq} was computed as the average of the last 3 years, but rescaled to the F(2-8) of 2010 ($F_{stq} = 0.64$).

Weight-at-age in the stock

PERIOD	Age	1	2	3	4	5	6	7	8
2010	Mean weight in stock (kg)	0.004	0.012	0.022	0.032	0.043	0.053	0.061	0.069

Weight-at-age in the catch

PERIOD	Age	1	2	3	4	5	6	7	8
2010	Mean weight in catch (kg)	0.004	0.012	0.022	0.032	0.043	0.053	0.061	0.069

Number at age in the catch

PERIOD	Age	1	2	3	4	5	6	7	8
2008	Catch at age in numbers (thousands)	1187.293	1296.802	780.535	519.201	262.524	146.529	45.213	7.267
2009		652.145	1285.316	1882.003	1339.126	435.601	123.253	41.839	5.414
2010		863.788	2268.645	3511.779	1880.460	505.980	113.699	29.175	.641

Number at age in the stock

PERIOD	Age	1	2	3	4	5	6	7	8
2008	Stock numbers	12740.517	7367.927	3486.050	1631.132	704.329	283.570	81.050	21.124
2009	at age	26821.963	12209.344	6466.592	2790.178	828.109	225.762	58.907	7.611
2010	(thousands)	40849.752	18683.743	9659.545	3593.991	936.750	243.937	80.247	1.863

Stock recruitment

For the short term projection a guess estimation of recruitment (24 millions) was computed as the geometric mean from 2008-2010.

7.13.1.3 Results

A short term projection (Table 7.13.1.3.1), assuming an F_{stq} of 0.64 and a recruitment of 24 millions individuals, shows that:

- Fishing at the F_{stq} from 2012 to 2013 generates a decrease of about 14% in SSB and from 2010 to 2012 a decrease of about 11 %.in catch

- Fishing at $F_{0.1}$ (0.32) for the same time frame gives a very slight increase of about 1% in the spawning stock biomass and a decrease of about 49% in catches

- The analysis shows that in order to reach $F_{0.1}$, a decrease of F_{stq} by 49% is needed.

- EWG 11-20 recommends that fishing mortality in 2012 should not exceed $F_{0.1}$ = 0.5, corresponding to catches of about 100 t.

Outlook until 2013

Table 7.13.1.3.1. Short term forecast in different F scenarios computed for giant red shrimp in GSA 9.

Basis: Fstq = F (2010) rescaled (Fbar 2-8); R (2011) = GM (2008–2010) = 24 (millions); F (2011) = 0.64; SSB (2012) = 582t; Catch (2010) = 197t. Weight sin tons.

Rationale	F scenario	F factor	Catch 2012 (t)	SSB 2013 (t)	Change SSB 2012 -2013 (%)	Change Catch 2010 -2012 (%)
Zero catch	0.00	0.000	0.000	700.908	20.29	-100.00
High long term yield ($F_{0.1}$)	0.32	0.503	100.104	587.811	0.88	-49.37
Status quo	0.64	1.000	176.905	501.718	-13.90	-10.53
Different scenarios	0.06	0.100	22.048	675.928	16.00	-88.85
	0.13	0.200	42.968	652.261	11.94	-78.27
	0.19	0.300	62.825	629.828	8.09	-68.23
	0.25	0.400	81.684	608.556	4.44	-58.69
	0.32	0.500	99.603	588.376	0.98	-49.62
	0.38	0.600	116.636	569.222	-2.31	-41.01
	0.45	0.700	132.836	551.034	-5.43	-32.82
	0.51	0.800	148.251	533.756	-8.40	-25.02
	0.57	0.900	162.927	517.334	-11.22	-17.60
	0.70	1.100	190.226	486.861	-16.45	-3.79
	0.76	1.200	202.926	472.721	-18.87	2.63
	0.83	1.300	215.042	459.255	-21.18	8.76
	0.89	1.400	226.605	446.425	-23.38	14.61
	0.95	1.500	237.646	434.196	-25.48	20.19
	1.02	1.600	248.195	422.533	-27.49	25.53
	1.08	1.700	258.279	411.405	-29.39	30.63
	1.15	1.800	267.922	400.782	-31.22	35.51
	1.21	1.900	277.150	390.636	-32.96	40.17
	1.27	2.000	285.984	380.940	-34.62	44.64

7.14 Giant red shrimp (*Aristaeomorpha foliacea*) in GSA 9

7.14.1 Short term prediction 2011-2013

7.14.1.1 Method and justification

Short term predictions for 2012 and 2013 were implemented in R (www.r-project.org) using the FLR libraries and based on the results of Length Cohort Analysis (LCA) carried out on 2008-2010 of catch data collected under DCF.

7.14.1.2 Input parameters

The following data have been used to derive the input data for the short term projection of the giant red shrimp stock in GSA9:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4	5	6	7
2010	Prop. Matures	0.4	0.8	1.0	1.0	1.0	1.0	1.0	1.0

PERIOD	Age	0	1	2	3	4	5	6	7
2010	M	0.76	0.50	0.41	0.36	0.34	0.32	0.31	0.30

F vector

PERIOD	Age	0	1	2	3	4	5	6	7
2008	F	0.002	0.218	0.373	0.884	1.825	0.418	0.782	0.500
2009		0.002	0.197	0.673	1.055	1.196	0.595	0.351	0.338
2010		0.011	0.445	1.001	1.098	2.086	0.538	0.791	0.500
Mean 2008-2010 rescaled		0.006	0.350	0.834	1.237	2.081	0.632	0.784	0.545

Fstq was computed as the average of the last 3 years, but rescaled to the F(1-5) of 2010 (F_{stq} = 1.03).

Weight-at-age in the stock

PERIOD	Age	0	1	2	3	4	5	6	7
2010	Mean weight in stock (kg)	0.002	0.011	0.022	0.032	0.039	0.046	0.073	0.078

Weight-at-age in the catch

PERIOD	Age	0	1	2	3	4	5	6	7
2010	Mean weight in catch (kg)	0.002	0.011	0.022	0.032	0.039	0.046	0.073	0.078

Number at age in the catch

PERIOD	Age	0	1	2	3	4	5	6	7
2008	Catch at age in numbers (thousands)	5.859	824.861	378.565	263.162	96.010	3.796	2.305	.538
2009		18.556	511.541	621.944	265.402	64.881	8.962	2.027	1.026
2010		145.456	1701.431	990.536	233.501	65.800	2.350	1.101	.257

Number at age in the stock

PERIOD	Age	0	1	2	3	4	5	6	7
2008	Stock numbers at age (thousands)	10492.539	2741.423	713.897	209.682	42.979	7.292	1.576	0
2009		14010.991	4004.284	1574.590	485.091	110.052	23.087	7.883	4.094
2010		24614.706	6660.789	1957.676	419.387	88.565	6.583	2.323	.749

Stock recruitment

For the short term projection a guess estimation of recruitment (15 millions) was computed as the geometric mean from 2008-2010.

7.14.1.3 Results

A short term projection (Table 7.14.1.3.1), assuming an F_{stq} of 1.03 and a recruitment of 15 millions individuals, shows that:

- Fishing at the F_{stq} from 2012 to 2013 generates a decrease in SSB of about 14%.and from 2010 to 2012 a decrease in catch of about 7 %.
- Fishing at $F_{0.1}$ (0.50) for the same time frame generates a slight increase in the spawning stock biomass of about 3% and a decrease in catches of about 45%
- The analysis shows that in order to reach $F_{0.1}$, a decrease of F_{stq} by 52% is needed.
- EWG 11-20 recommends that fishing mortality in 2012 should not exceed $F_{0.1}$ = 0.5, corresponding to

catches of about 28 t.

Outlook until 2013

Table 7.14.1.3.1. Short term forecast in different F scenarios computed for giant red shrimp in GSA 9.

Basis: Fstq = F (2010) rescaled (Fbar 1-5); R (2011) = GM (2008–2010) = 15 (millions); F (2011) = 1.03; SSB (2012) = 123t; Catch (2010) = 51t. Weights in tons.

Rationale	F scenario	F factor	Catch 2012 (t)	Catch 2013 (t)	SSB 2013 (t)	Change SSB 2012 -2013 (%)	Change Catch 2010 -2012 (%)
Zero catch	0.00	0.00	0.0	0.0	156.9	27.89	-100.00
High long term yield ($F_{0.1}$)	0.50	0.48	27.8	31.1	126.2	2.84	-45.38
Status quo	1.03	1.00	47.3	39.4	105.0	-14.39	-7.07
Different scenarios	0.10	0.10	6.7	10.0	149.4	21.81	-86.83
	0.21	0.20	12.8	17.7	142.7	16.27	-74.78
	0.31	0.30	18.5	23.6	136.4	11.21	-63.73
	0.41	0.40	23.6	28.1	130.8	6.57	-53.58
	0.51	0.50	28.4	31.5	125.5	2.32	-44.24
	0.62	0.60	32.8	34.1	120.7	-1.59	-35.62
	0.72	0.70	36.9	36.1	116.3	-5.18	-27.65
	0.82	0.80	40.6	37.6	112.3	-8.50	-20.27
	0.92	0.90	44.1	38.6	108.5	-11.56	-13.43
	1.13	1.10	50.4	39.9	101.8	-17.02	-1.15
	1.23	1.20	53.2	40.2	98.8	-19.45	4.36
	1.33	1.30	55.8	40.4	96.1	-21.71	9.51
	1.44	1.40	58.2	40.5	93.5	-23.81	14.33
	1.54	1.50	60.5	40.5	91.1	-25.77	18.83
	1.64	1.60	62.7	40.5	88.8	-27.59	23.06
	1.74	1.70	64.7	40.4	86.7	-29.30	27.03
	1.85	1.80	66.6	40.3	84.8	-30.89	30.76
	1.95	1.90	68.4	40.1	83.0	-32.38	34.28
	2.05	2.00	70.1	39.9	81.2	-33.77	37.59

7.15 Norway lobster (*Nephrops norvegicus*) in GSA 9

7.15.1 Short term prediction 2011-2013

7.15.1.1 Method and justification

Short term predictions were implemented in R (www.r-project.org) using the FLR libraries and based on the results of Length Cohort Analysis (LCA) carried out on 2010 catch data collected under DCF.

7.15.1.2 Input parameters

The following data have been used to derive the input data for the short term projection of Norway lobster in the GSA 09:

Maturity vector

PERIOD	Age	0	1	2	3	4	5	6	7	8	9
2010	Prop. Matures	0.0	0.2	0.5	0.9	1.0	1.0	1.0	1.0	1.0	1.0

M vector

PERIOD	0	1	2	3	4	5	6	7	8	9
2010	1.0	0.6	0.4	0.23	0.2	0.2	0.2	0.2	0.2	0.2

The F vector was computed from the average of the F vectors of the last 3 years, rescaled to the F_{bar} (F_{3-6}) in 2010.

F vector

F	0	1	2	3	4	5	6	7	8	9
2010	0.01	0.11	0.31	0.34	0.31	0.30	0.43	0.35	0.30	0.29

Weight-at-age in the stock

Mean weight in stock (kg)	0	1	2	3	4	5	6	7	8	9
2010	0.002	0.007	0.018	0.032	0.048	0.066	0.084	0.102	0.118	0.134

Weight-at-age in the catch

Mean weight in catch (kg)	0	1	2	3	4	5	6	7	8	9
2010	0.002	0.007	0.018	0.032	0.048	0.066	0.084	0.102	0.118	0.134

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2	3	4	5	6	7	8	9
2010	162	1348	2744	866	489	271	113	21	14	2

Number at age in the stock

Stock numbers at age (thousands)	0	1	2	3	4	5	6	7	8	9
2010	24595	16354	9859	4362	2215	1084	505	245	147	87

Maturity was estimated as the mean of the last 3 years. A vector of M coming from Prodbiom estimation was used.

7.15.1.3 Results

A short term prediction (Table 7.15.1.3.1), assuming an F_{stq} of 0.35 ($F_{3\text{-}6}$) in 2011 and a recruitment of 32.9 million individuals shows that:

- Fishing at the F_{stq} (0.35) from 2010 to 2012 is expected to produce a slight increase in catch (8%) and a decrease of the spawning stock biomass (-5.7%) from 2012 to 2013.

- Fishing at F_{MSY} (0.21) generates a short term decrease of the catches (-30%) between 2010 and 2012, and a spawning stock biomass slight increase (6%) from 2012 to 2013.

- STECF-EWG 11-20 advice considers the stock overexploited being the current F (0.35) higher than the candidate reference point (F_{MSY}) of 0.21.

- EWG 11-20 recommends that in 2013 fishing mortality should not exceed the value of F_{MSY} = 0.21, which corresponds to a catch of 106 tons.

Outlook until 2013

Table 7.15.1.3.1. Short term forecast in different F scenarios computed for Norway lobster in GSA 9. Catch and SSB are in tons.

Basis: F (2010) = mean (Fbar2006–2008); R (2010) = GM (2006–2010) = 32.9 (millions) individuals; F (2010) = 0.35; SSB (2011) = 560 t; Catch (2011) = 159 t. Weights in tons.

Rationale	F scenario	F factor	Catch 2012	Catch 2013	SSB 2013	Change SSB 2012-2013 (%)	Change Catch 2010-2012 (%)
zero catch	0.00	0.0	0	0	706	27.3	-100.0
High long-tem yield (F_{MSY})	0.21	0.6	98	106	588	6.0	-30.2
Status quo	0.35	1.0	153	147	523	-5.7	8.6
Different scenarios	0.03	0.1	18	22	685	23.5	-87.6
	0.07	0.2	34	42	665	19.8	-75.5
	0.10	0.3	51	60	645	16.2	-63.8
	0.14	0.4	67	76	626	12.8	-52.5
	0.17	0.5	82	91	607	9.4	-41.5
	0.21	0.6	97	105	589	6.2	-30.8
	0.24	0.7	112	117	572	3.1	-20.5
	0.28	0.8	126	128	555	0.0	-10.5
	0.31	0.9	140	138	539	-2.9	-0.8
	0.38	1.1	166	155	508	-8.5	17.7
	0.42	1.2	178	162	493	-11.1	26.6
	0.45	1.3	190	169	479	-13.7	35.2
	0.48	1.4	202	174	465	-16.2	43.5
	0.52	1.5	213	179	452	-18.6	51.6
	0.55	1.6	224	183	439	-21.0	59.4
	0.59	1.7	235	187	426	-23.2	67.0
	0.62	1.8	245	190	414	-25.4	74.4
	0.66	1.9	255	193	402	-27.5	81.5
	0.69	2.0	265	195	391	-29.6	88.5

7.16 Mantis shrimp (*Squilla mantis*) in GSA 9

7.16.1 Short term prediction 2011-2013

7.16.1.1 Method and justification

Short term predictions were implemented in R (www.r-project.org) using the FLR libraries and based on the results of Length Cohort Analysis (LCA) carried out on 2009 and 2010 catch data collected under DCF.

7.16.1.2 Input parameters

The following data have been used to derive the input data for the short term projection of mantis shrimp in the GSA 9:

Maturity vector (from 2010 data)

PERIOD	Age	0	1	2	3	4	5
2010	Prop. Matures	0.04	0.89	1.0	1.0	1.0	1.0

Constant M

PERIOD	0	1	2	3	4	5
2010	0.5	0.5	0.5	0.5	0.5	0.5

The F vector was computed by means of LCA performed using the Vit software. Results obtained in 2009 using the same procedure are consistent with those obtained in 2010. Therefore, no average or rescaling was computed.

F vector

F	0	1	2	3	4	5
2010	0.04	0.58	1.71	1.98	0.68	0.31

Weight-at-age in the stock

Mean weight in stock (kg)	0	1	2	3	4	5
2010	0.005	0.02	0.033	0.044	0.052	0.057

Weight-at-age in the catch

Mean weight in catch (kg)	0	1	2	3	4	5
2010	0.005	0.02	0.033	0.044	0.052	0.057

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2	3	4	5
2010	1390	9090	5740	663	32	5

Number at age in the stock

Stock numbers at age (thousands)	0	1	2	3	4	5
2010	45490	26509	9000	988	83	25

7.16.1.3 Results

A short term prediction (Table 7.16.1.3.1), assuming an F_{stq} of 1.24 ($F_{1\text{-}4}$) in 2011 and a recruitment of 44.6 million individuals has been performed. The recruitment has been computed as the average of the recruitment in 2009 and 2010, which are very consistent (43.7 and 45.5 million of individuals in 2009 and 2010, respectively). The results of the short term forecast analysis are the following:

- Fishing at the F_{stq} (1.24) from 2010 to 2012 is expected to produce a slight increase in catch (6%); no appreciable change should be observed in SSB from 2012 to 2013.

- Fishing at F_{MSY} (0.54) generates a short term decrease of the catch (-40%) from 2010 to 2012, and an increase in the spawning stock biomass (25%) between 2012 and 2013.

- STECF EWG 11-20's advice considers the stock overexploited being the current F (1.24) higher than the candidate reference point (F_{MSY}) of 0.54.

- STECF EWG 11-20 recommends that in 2013 fishing mortality should not exceed the value of F_{MSY} = 0.54, which corresponds to a catch of 332 tons.

Outlook until 2013

Table 7.16.1.3.1. Short term forecast in different F scenarios computed for mantis shrimp in GSA 9. Catch and SSB are in tons.

Basis: F (2010) = Fbar(2010); R (2010) = GM(2009-2010) = 44.6 (millions) individuals; F_{MSY} (2010) = 0.54; SSB (2011) = 831 t; Catch (2011) = 433 t. Weights in tons.

Rationale	F scenario	F factor	Catch 2012	Catch 2013	SSB 2013	Change SSB 2012-2013 (%)	Change Catch 2010-2012 (%)
zero catch	0.00	0.0	0	0	1289	56.9	-100.0
High long-tem yield (FMSY)	0.54	0.4	244	326	1019	24.0	-40.5
Status quo	1.24	1.0	430	426	816	-0.7	5.0
Different scenarios	0.12	0.1	67	116	1214	47.8	-83.6
	0.25	0.2	127	202	1148	39.7	-69.0
	0.37	0.3	180	265	1089	32.6	-56.0
	0.50	0.4	228	312	1037	26.2	-44.4
	0.62	0.5	270	348	990	20.5	-33.9
	0.74	0.6	309	374	948	15.3	-24.6
	0.87	0.7	343	393	910	10.7	-16.1
	0.99	0.8	375	407	876	6.5	-8.4
	1.11	0.9	404	418	844	2.7	-1.4
	1.36	1.1	454	431	790	-3.9	10.9
	1.49	1.2	476	436	766	-6.8	16.2
	1.61	1.3	496	439	744	-9.4	21.2
	1.73	1.4	515	441	724	-11.9	25.8
	1.86	1.5	532	442	705	-14.2	30.1
	1.98	1.6	549	443	688	-16.3	34.0
	2.10	1.7	564	443	672	-18.3	37.7
	2.23	1.8	578	443	657	-20.1	41.1
	2.35	1.9	591	443	642	-21.8	44.4
	2.48	2.0	603	443	629	-23.4	47.4

7.17 European hake (*Merluccius merluccius*) in GSA 10

7.17.1 Short term prediction 2012 - 2013

7.17.1.1 Method and justification

Short term prediction for 2012 and 2013 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the stock assessment performed using VIT (Lleonart and Salat, 1997) that was conducted in the framework of the EWG 11-20 using the VPA Lowestoft routines.

7.17.1.2 Input parameters

The following data have been used to derive the input data for the short term projection of the hake in the GSA 10:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4	5	6	7	8
2008-2010	Prop. Matures	0.0	0.19	0.86	1.0	1.0	1.0	1.0	1.0	1.0

PERIOD	Age	0	1	2	3	4	5	6	7	8	Mean 0-4
2008-2010	M	1.16	0.53	0.40	0.35	0.32	0.30	0.30	0.30	0.30	0.46

F vector

F	0	1	2	3	4	5	6	7	8
2008	0.318	1.232	0.578	0.572	0.873	0.614	0.32		
2009	0.416	1.605	0.846	0.41	0.507	0.375	0.406	0.32	
2010	0.194	1.457	1.523	0.953	0.172	0.332	0.462	0.217	0.32
2011*	0.3337	1.544	1.0596	0.6958	0.558	0.475	0.4272	0.2897	0.3452

*geometric mean of the last three years rescaled to 2010

Several scenarios with different harvest strategy were run, with F_{stq} (F_{bar} ages 0-6) calculated as the average of the last 3 years, but rescaled to the F of 2010 (F_{stq} =0.73). These short term predictions were done without taking into account the change in the mesh as adopted by Council Regulation (EC) No 1967/2006 of 21 December 2006.

Weight-at-age in the stock

Mean weight in stock	0	1	2	3	4	5	6	7	8
kg	0.01	0.11	0.46	1.08	1.91	2.77	3.66	4.54	5.34

Weight-at-age in the catch

Mean weight in catch	0	1	2	3	4	5	6	7	8
kg	0.01	0.11	0.46	1.08	1.91	2.77	3.66	4.54	5.34

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2	3	4	5	6	7	8
2010	3952	6069	890	102	7	8	6	1	1

Number at age in the stock

Stock at age in numbers (thousands)	0	1	2	3	4	5	6	7	8
2010	37084	9583	1317	192	52	32	17	8	5
2011	34650	8335	1207	306	68	22	15	8	7

Stock recruitment

The recruitment used for the short term projection was estimated as the geometric mean from 2008-2010 (29636, 37084, 37853 in thousands).

7.17.1.3 Results

A short term projection (Table 7.17.1.3.1), assuming an F_{stq} of 0.73 in 2011 and a recruitment of 34650 (thousands) individuals, shows that:

- Fishing at the F_{stq} (0.73) from 2010 to 2012 generates a decrease of the catch for 11.8 % and a decrease of the spawning stock biomass of 2.9% from 2012 to 2013.

- Fishing at $F_{0.1}$ (0.17) from 2010 to 2012 generates a decrease of the catch of 70.3% and a spawning stock biomass increase of 113.7% from 2012 to 2013.

- A 30% reduction of the F_{stq} (F=0.51) generates a decrease of catch for 29.6% in 2012 and an increase of spawning stock biomass of about 30.4% from 2012 to 2013, indicating that this level of reduction could generate a slight decrease of catches but a significant increase of the spawning stock biomass.

- EWG 11-20 recommends that fishing mortality in 2011 should not exceed $F_{0.1}$= 0.17, corresponding to catches of 384 tons.

Outlook for 2012-2013

Table 7.17.1.3.1. Short term forecast in different F scenarios computed for hake in GSA 10.

Rationale	F scenario	F factor	Catch 2012	Catch 2013	SSB 2013	Change SSB 2013-2012 (%)	Change Catch 2012-2010 (%)
zero catch	0	0.0	0	0	3558	179.0	-100.0
High long-term yield ($F_{0.1}$)	0.17	0.2	384	687	2725	113.7	-70.3
Status quo	0.73	1.0	1140	1115	1239	-2.9	-11.8
Different scenarios	0.07	0.1	175	355	3172	148.7	-86.4
	0.15	0.2	332	614	2834	122.2	-74.3
	0.22	0.3	473	801	2536	98.9	-63.4
	0.29	0.4	600	932	2275	78.4	-53.6
	0.36	0.5	714	1020	2045	60.3	-44.7
	0.44	0.6	817	1077	1842	44.4	-36.8
	0.51	0.7	910	1109	1663	30.4	-29.6
	0.58	0.8	994	1123	1504	17.9	-23.1
	0.65	0.9	1070	1124	1364	6.9	-17.1
	0.80	1.1	1203	1099	1128	-11.6	-6.9
	0.87	1.2	1261	1078	1029	-19.3	-2.4
	0.95	1.3	1314	1053	941	-26.2	1.7
	1.02	1.4	1363	1027	862	-32.4	5.5
	1.09	1.5	1408	999	792	-37.9	9.0
	1.16	1.6	1449	970	729	-42.9	12.2
	1.24	1.7	1487	942	672	-47.3	15.1
	1.31	1.8	1522	913	620	-51.4	17.8
	1.38	1.9	1555	885	574	-55.0	20.4
	1.46	2.0	1585	858	532	-58.3	22.7

Respect to the previous short term forecasts (SGMED 03-2010) the observed production for 2010 was 1291 tons, while the predicted catch was 1133 tons. Respect to the short terms forecasts at SGMED 03-2009 that were performed using ALADYM the predicted catches of 2010 were 1122 tons. The difference between the predicted and observed values were 12.2% for the forecasts of 2010 and 13% for the forecasts of 2009. These differences were probably due to the assumption made to project the population in 2010 (F maintained at level estimated in 2009 =0.61 and as estimated in 2008 F=0.56). Instead, the F estimated in 2010 is 0.73 and this could explain the difference between observed and estimated production. Finally, the recruitment hypothized in the forecast for 2010 was similar to the recruitment estimated by VIT for 2010.

7.17.2 Medium term prediction

7.17.2.1 Method and justification

Medium term prediction from 2011 to 2020 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of stock assessment obtained using VIT (Lleonart and Salat, 1997) and the VPA Lowestoft routines. Medium term prediction should be taken with caution considering the assumptions of steady state in the assessment. However, medium term projections (20 years) were run simulating 4 management scenarios assuming:

- a progressive decreasing trend of F toward $F_{0.1}$ until 2020 (annual reduction of 14.9%)
- a progressive decreasing trend of F toward $F_{0.1}$ until 2015 (annual reduction of 30.4%)
- a sharp decreasing to $F_{0.1}$ level from 2012 (76.5% of reduction in 2012)
- an annual decrease of 10% until 2020

The stock-recruitment relationship used geometric mean recruitment over the observed SSB range from 2008 to 2010. Runs were made with 500 simulations per run. To simulate a stochastic process the recruitment was multiplied by log-normally distributed noise with mean 1 and standard deviation 0.3.

7.17.2.2 Input parameters

The maturity ogives, the natural mortality, the numbers of individuals and weight-at-age for the stock and for the catch were the same used in the short term forecast.

7.17.2.3 Results

In figures Fig. 7.17.2.3.1 (a and b), Fig. 7.17.2.3.2 (c and d) the 5th, 25th, 50th, 75th and 95th percentile are respectively showed for the SSB, recruitment and catches in t from 2010 to 2020, for the 4 scenarios.

Landings of hake from 2004 to 2010 in the GSA10 are reported in the table 7.17.2.3.1 and show a decreasing pattern until 2009 and a value similar to 2007 in 2010. In all the 4 scenarios of the medium-term forecasts the decreasing of fishing mortality results in a clear increase of the SSB, while the amount of the catches also increased in the medium term. In the scenario with a sharp decrease of F towards $F_{0.1}$ the catch reduction is remarkable compared to the other ones. In the scenario reducing fishing mortality of 10% by year to 2020 the final F value is 0.28.

Table 7.17.2.3.1. Landings of hake in the GSA 10.

Year	2004	2005	2006	2007	2008	2009	2010
DCF landings	1339	1485	1544	1269	1123	1091	1291

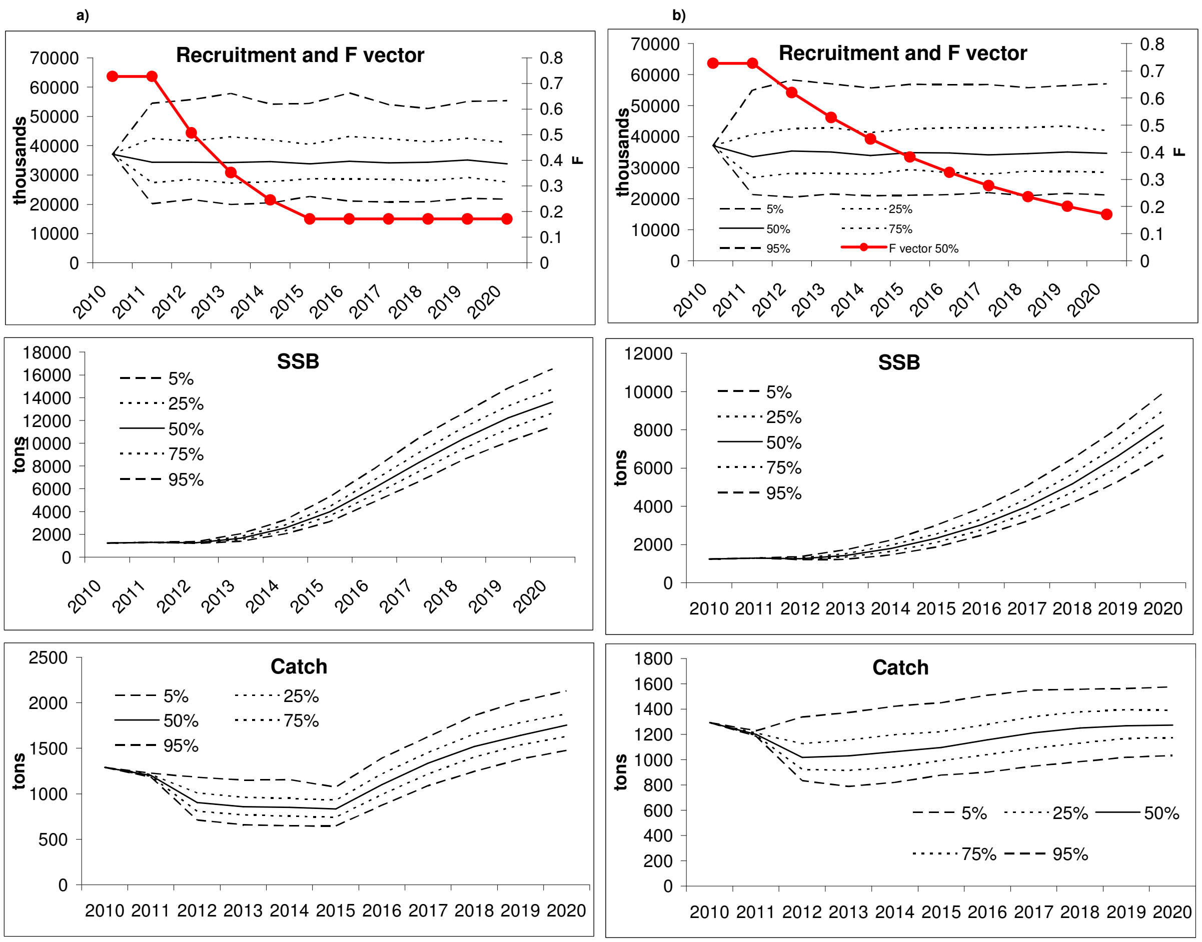


Fig. 7.17.2.3.1 Output of the medium term forecast computed for the hake in the GSA 10 reaching the $F_{0.1}$ in 2015 (a) and 2020 (b).

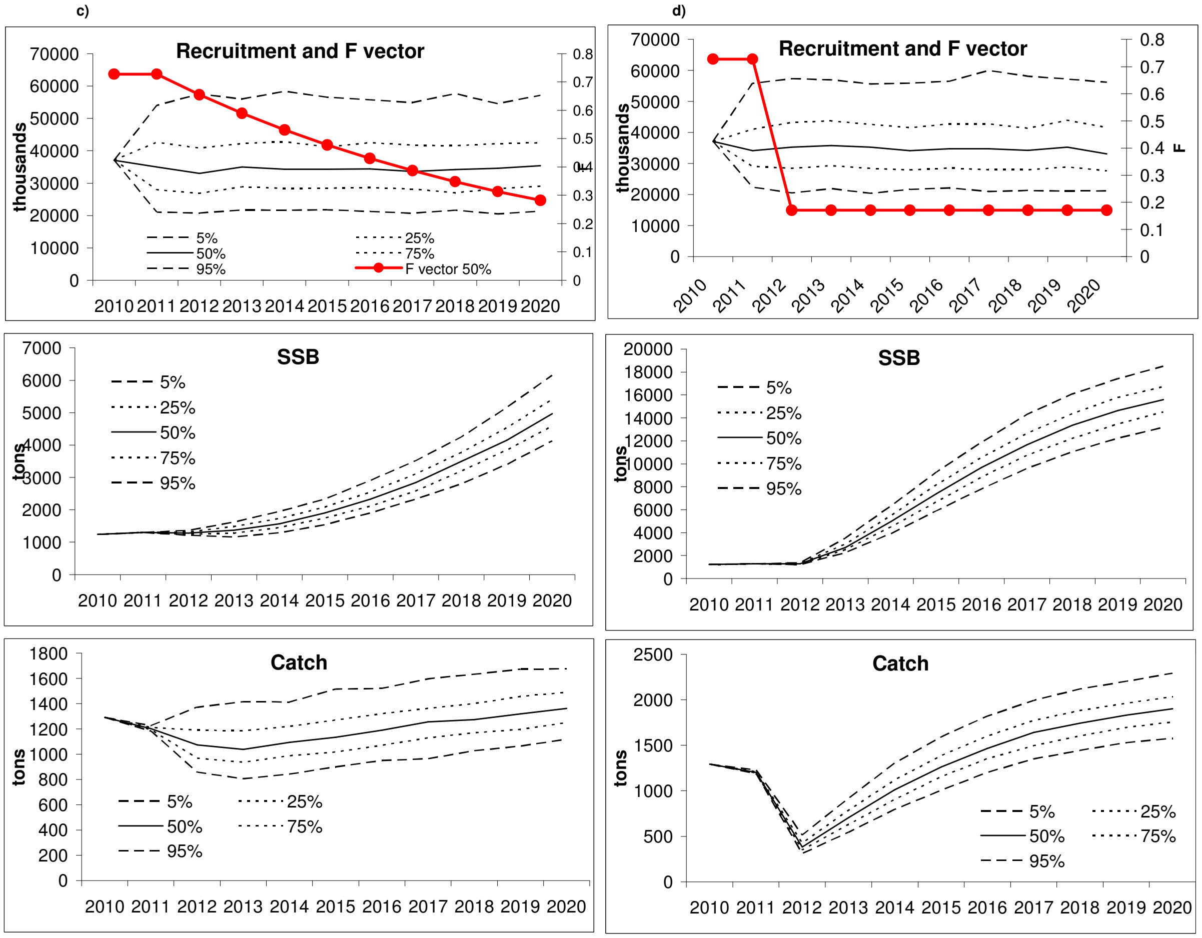


Fig. 7.17.2.3.2. Output of the medium term forecast computed for the hake in the GSA 10 with F decreasing 10% per year until 2020 (c) and with F = $F_{0.1}$ from 2012 to 2020 (d).

7.18 Red mullet (*Mullus barbatus*) in GSA 10

7.18.1 Short term prediction 2011-2013

7.18.1.1 Method and justification

Short term prediction for 2010-2012 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the stock assessment performed using VIT (Lleonart and Salat, 1997) that was conducted in the framework of the EWG 11-20 using the VPA Lowestoft routines.

7.18.1.2 Input parameters

The following data have been used to derive the input data for the short term projection of the red mullet in the GSA 10:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4	5
2008-2010	Prop. Matures	0.16	0.92	1.00	1.00	1.00	1.00

PERIOD	Age	Mean
2008-2010	M	0.61

F vector

F	0	1	2	3	4	5
2008	0.271	1.328	2.304	2.284	0.700	
2009	0.486	1.444	1.537	0.727	0.700	
2010	0.306	1.982	1.567	0.824	0.727	0.700
2011*	0.334	1.495	1.701	1.206	0.669	0.661

* geometric mean of the last three years rescaled to 2010

Several scenarios of constant harvest strategy with with F_{stq} (F_{bar} ages 0-5) calculated as the average of the last 3 years, but rescaled to the F of 2010 (Fstq =1.01). Potential changes in selectivity due to the implementation of the 40 mm square/50mm diamond mesh size on trawlers based on EC 1967/2006 were not taken into account in the predictions.

Weight-at-age in the stock

Mean weight in stock	0	1	2	3	4	5
kg	0.0060	0.0307	0.0781	0.1306	0.1749	0.2102

Weight-at-age in the catch

Mean weight in catch	0	1	2	3	4	5
kg	0.0060	0.0307	0.0781	0.1306	0.1749	0.2102

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2	3	4	5
2010	3029	4272	289	22	5	1

Number at age in the stock

Stock at age in numbers (thousands)	0	1	2	3	4	5
2010	15100	6040	452	51	12	3
2011	21302	5986	801	49	9	4

Stock recruitment

The recruitment used for the short term projection was estimated as the geometric mean from 2008-2010 (24724, 25892, 15100, in thousands).

7.18.1.3 Results

A short term projection (Table 7.18.1.3.1), assuming an F_{stq} of 1.01 in 2011 and a recruitment of 21302 (thousands) individuals, shows that:

- Fishing at the F_{stq} (=1.01) generates an increase of the catch for 30% from 2010 to 2012 and an increasing of the spawning stock biomass of 7% from 2012 to 2013.
- Fishing at $F_{0.1}$ (0.4) generates a decrease of the catch of 31% from 2010 to 2012 and a spawning stock biomass increase of 67% from 2012 to 2013.
- A 30% reduction of the F_{stq} (F=0.71) generates a increase of catch of 6% from 2010 to 2012 and an increase of spawning stock biomass of about 31% from 2012 to 2013, indicating that this level of reduction could generate an slight increase of catches but an important increase of the spawning stock biomass.

STECF EWG 11-20 recommends that fishing mortality in 2012 should not exceed $F_{0.1}$ = 0.4, corresponding to catches of 121 tons.

Outlook for 2012-2013

Table 7.18.1.3.1 - Short term forecast in different F scenarios computed for red mullet in GSA 10.

Basis: F (2011) = F (2010) rescaled (F_{bar}1-5); R (2011)=GM (2008–2010) = 21302 (thousands); F (2011) =1.01; SSB (2012) = 322; Catch (2011)=183 t. Weights in tons.

Rationale	F scenario	F factor	Catch 2012	Catch 2013	SSB 2013	Change SSB 2012-2013 (%)	Change Catch 2010-2012 (%)
Zero catch	0.000	0	0	0	758	135.44	-100.00
High long-term yield ($F_{0.1}$)	0.4	0.4	121	199	538	67.08	-31.28
Status quo	1.011	1	230	245	345	7.26	30.41
Different scenarios	0.101	0.1	37	79	690	114.19	-78.80
	0.202	0.2	70	135	630	95.58	-60.11
	0.303	0.3	99	175	577	79.24	-43.62
	0.404	0.4	125	203	531	64.87	-29.02
	0.506	0.5	148	221	490	52.19	-16.08
	0.607	0.6	168	233	454	40.97	-4.58
	0.708	0.7	186	240	422	31.03	5.67
	0.809	0.8	202	244	394	22.19	14.83
	0.910	0.9	217	246	368	14.31	23.04
	1.112	1.1	242	244	325	0.93	37.05
	1.213	1.2	252	241	307	-4.77	43.05
	1.314	1.3	262	238	290	-9.91	48.48
	1.416	1.4	270	235	275	-14.58	53.43
	1.517	1.5	278	231	261	-18.82	57.93
	1.618	1.6	286	227	249	-22.70	62.05
	1.719	1.7	292	223	238	-26.25	65.83
	1.820	1.8	298	220	227	-29.51	69.31
	1.921	1.9	304	216	217	-32.52	72.52
	2.022	2.0	309	212	208	-35.30	75.49

Respect to the previous short term forecasts (SGMED 10-03) the observed production for 2010 was 176 tons, while the predicted catch was 279 tons. The difference between the 2 values (about -56 %) is probably due to the assumption made on the recruitment when projecting the population in 2010: 30,474 thousands was the recruitment hypothesized in the forecast for 2010 that is very different from the recruitment estimated by VIT for 2010 (15,100 thousands).

Given these high variations and uncertainty of recruitment it was decided to not perform the medium terms forecasts.

7.19 Pink shrimp (*Parapaeneus longirostris*) in GSA 10

7.19.1 Short term prediction for 2010 and 2011

7.19.1.1 Method and justification

Short term prediction for 2011 and 2012 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the stock assessment performed using VIT (Lleonart and Salat, 1997) that was conducted in the framework of the EWG 11-20 using the VPA Lowestoft routines.

7.19.1.2 Input parameters

The following data have been used to derive the input data for the short term projection of pink shrimp in the GSA 10.

Maturity and M vectors

PERIOD	Age	0	1	2+
2008-2010	Prop. Matures	0.47	0.98	1.00

PERIOD	Age	0	1	2	Mean 0-2+
2008-2010	M	1.41	0.81	0.70	1

F vector

F	0	1	2+
2008	0.559	2.784	1
2009	0.338	2.213	1
2010	0.34	1.985	1
2011*	0.367	2.069	0.889

*geometric mean of 2008-2010 rescaled to 2010

Several scenarios with different harvest strategy were run, with F_{stq} (F_{bar} ages 0-2+) calculated as the average of the last 3 years, but rescaled to the F of 2010 (F_{stq} = 1.1).

These short term predictions were done without taking into account the change in the mesh as adopted by Council Regulation (EC) No 1967/2006 of 21 December 2006.

Weight-at-age in the stock

Mean weight in stock	0	1	2+
G	2.01	10.21	22.33

Weight-at-age in the catch

Mean weight in catch	0	1	2+
G	2.01	10.21	22.33

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2+
2010	36110	26034	1404

Number at age in the stock

Stock at age in numbers (thousands)	0	1	2+
2010	224766	39046	2387
2011	239176	38033	2681

Stock recruitment

The recruitment used for the short term projection was estimated as the geometric mean from 2008-2010 (239,175 thousands).

7.19.1.3 Results

A short term projection (Table 7.19.1.3.1), assuming an F_{stq} of 1.1 in 2011 and a recruitment of 239,175 (thousands) individuals, shows that:

- Fishing at the F_{stq} (1.1) generates an increase of the catch of 5.3 % from 2010 to 2012 and an increase of the spawning stock biomass of 0.4% from 2012 to 2013.

- Fishing at $F_{0.1}$ (0.71) generates a decrease of the catch of 18.6 % from 2010 to 2012 and an increase of the spawning stock biomass of 17.5% from 2012 to 2013.

- A 30% reduction of the F_{stq} (F=0.78) generates a decrease of catch of 14% from 2010 to 2012 and an increase of spawning stock biomass of about 14.1 % from 2012 to 2013, indicating that this level of reduction could generate a decrease of catches but an equal increase of the spawning stock biomass.

EWG recommends that fishing mortality in 2012 should not exceed $F_{0.1}$ = 0.71, corresponding to catches of 300 t.

Outlook until 2013

Table 7.19.1.3.1. Short term forecast in different F scenarios computed for pink shrimp in GSA 10.

Basis: F (2011) = F (2010) rescaled (F_{bar} 0-2+); R (2011) = GM (2008–2010) = 239,175 (thousands); F (2011) = 1.1; SSB (2012) = 688; Catch (2011) = 372 t. Weights in tons.

Rationale	F scenario	F factor	Catch 2012	Catch 2013	SSB 2013	Change SSB 2012-2013 (%)	Change Catch 2010-2012 (%)
zero catch	0.00	0.0	0	0	1238	79.9	-100.0
High long-term yield ($F_{0.1}$)	0.71	0.6	301	353	809	17.5	-18.6
Status quo	1.11	1.0	389	391	691	0.4	5.3
Different scenarios	0.11	0.1	67	106	1140	65.6	-82.0
	0.22	0.2	124	185	1056	53.4	-66.4
	0.33	0.3	174	244	985	43.1	-53.0
	0.44	0.4	217	289	924	34.2	-41.3
	0.55	0.5	255	321	871	26.6	-31.0
	0.67	0.6	288	345	826	19.9	-22.0
	0.78	0.7	318	363	786	14.1	-14.0
	0.89	0.8	344	376	750	9.0	-6.8
	1.00	0.9	368	385	719	4.5	-0.5
	1.22	1.1	409	395	666	-3.2	10.5
	1.33	1.2	426	397	644	-6.5	15.3
	1.44	1.3	442	398	623	-9.5	19.7
	1.55	1.4	457	398	604	-12.2	23.7
	1.66	1.5	471	398	587	-14.8	27.4
	1.77	1.6	484	397	571	-17.1	30.9
	1.88	1.7	496	396	556	-19.3	34.1
	2.00	1.8	507	394	541	-21.3	37.2
	2.11	1.9	518	392	528	-23.2	40.0
	2.22	2.0	528	391	516	-25.0	42.7

Respect to the previous short term forecasts (SG-MED 10-03) the observed production for 2010 was 370 tons, while the predicted catch was 379 tons. The difference between the 2 values (less than 3%) is probably due to the difference between the recruitment hypothesized in the forecast for 2010 that was about 285,000 thousands, slightly different from the recruitment estimated by VIT for 2010 (224,700 thousands).

7.19.2 Medium term prediction

7.19.2.1 Method and justification

Medium term prediction from 2011 to 2020 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of stock assessment obtained using VIT (Lleonart and Salat, 1997) and the VPA Lowestoft routines. The medium term projections (20 years) were run simulating 4 management scenarios assuming:

- a progressive decreasing trend of F toward $F_{0.1}$ until 2020 (annual reduction of 4.8 %)
- a progressive decreasing trend of F toward $F_{0.1}$ until 2015 (annual reduction of 10.5 %)
- a sharp decreasing to $F_{0.1}$ level from 2012 (35% of reduction in 2012)
- an annual decrease of 10% until 2020

Runs were made with 500 simulations per run. To simulate a stochastic process the recruitment was multiplied by log-normally distributed noise with mean 1 and standard deviation 0.3.

7.19.2.2 Input parameters

The maturity ogive, the natural mortality, the numbers of individuals and weight-at-age for the stock and for the catch were the same used in the short term forecast.

7.19.2.3 Results

In Fig. 7.19.2.3.1 a, 7.19.2.3.1 b, 7.19.2.3.2 c and 7.19.2.3.2 d the 5th, 25th, 50th, 75th and 95th percentile are showed for the SSB, recruitment and catches in t from 2010 to 2020, for the 4 scenarios.

Landing data of pink shrimp from 2004 to 2009 in the GSA10 are reported in the table 7.19.2.3.1 and show an increasing pattern until 2006 and then a decreasing pattern, where the production in 2009 is one third of that in 2006. In all the 4 scenarios of the medium-term forecasts the decreasing of fishing mortality results in an increase of the SSB, while the catches in a medium term are fairly decreasing respect to the level observed in the last 2 years. In the scenario with a sharp decrease of F towards F0.1 the catch reduction is remarkable compared to the other ones. In the scenario reducing fishing mortality of 10% by year the final value of F is 0.43, that is about 39% lower than the target reference point adopted for this species.

Table 7.19.2.3.1 - Landings of pink shrimp in the GSA 10.

year	2004	2005	2006	2007	2008	2009	2010
DCF landings	552	776	1089	534	400	379	370

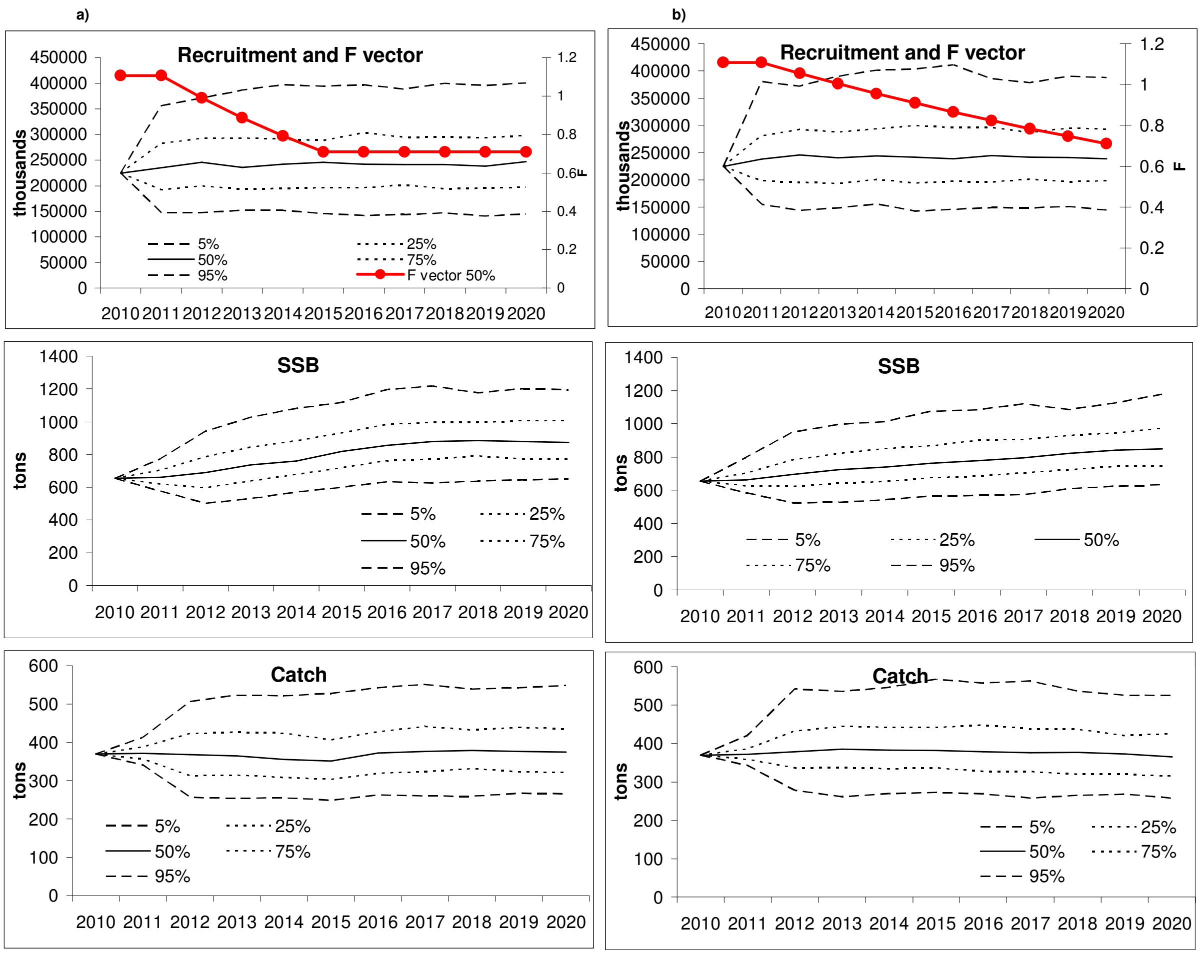


Fig. 7.19.2.3.1 Output of the medium term forecast computed for the pink shrimp in the GSA 10 reaching the $F_{0.1}$ in 2015 (a) and 2020 (b).

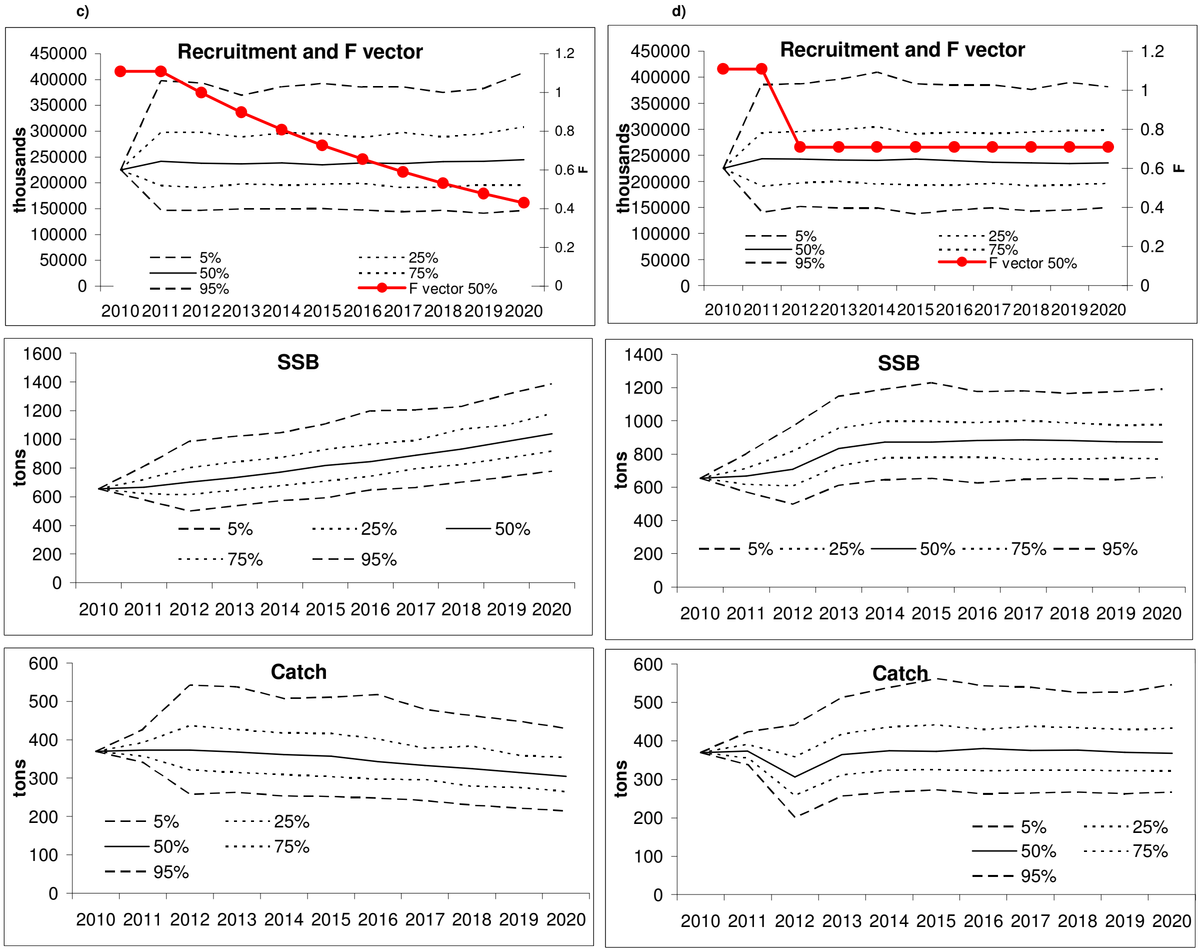


Fig. 7.19.2.3.1 Output of the medium term forecast computed for the pink shrimp in the GSA 10 with F decreasing 10% per year until 2020 (c) and with F = $F_{0.1}$ from 2012 to 2020 (d).

7.20 European hake (*Merluccius merluccius*) in GSA 11

7.20.1 Short term prediction 2011-2013

7.20.1.1 Method and justification

Short term predictions for 2010-2012 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the stock assessment performed using VIT (Lleonart and Salat, 1997) that was conducted during the EWG 11-12 and 11-20 meetings.

7.20.1.2 Input parameters

The following data have been used to derive the input data for the short term projection of the European hake in GSA 11:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4
2005-2010	Prop. Matures	0	0.1	0.9	1	1

PERIOD	Age	0	1	2	3	4
2005-2010	M	1.1	0.51	0.39	0.33	0.31

F vector

F	0	1	2	3	4
2006	0.292	0.578	0.647	0.178	0.044
2009	0.369	0.823	0.291	0.09	0.042
2010	0.33	0.983	0.745	0.12	0.044

Weight-at-age in the stock

Mean weight in stock (kg)	0	1	2	3	4
2006	0.005	0.011	0.072	0.198	0.388
2009	0.005	0.011	0.072	0.198	0.388
2010	0.005	0.011	0.072	0.198	0.388

Weight-at-age in the catch

Mean weight in catch (kg)	0	1	2	3	4
2006	0.005	0.011	0.072	0.198	0.388
2009	0.005	0.011	0.072	0.198	0.388
2010	0.005	0.011	0.072	0.198	0.388

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2	3	4
2006	2878	1549	249	159	75
2009	1539	853	70	15	4
2010	1125	698	126	12	2

Number at age in the stock

Stock numbers at age (in thousands)	0	1	2	3	4+
2006	19929	4954	1283	429	248
2009	8077	1859	432	214	138
2010	6693	1619	368	119	76
2011	6731	1585	364	152	97

*Geometric mean of the last two years (2009-2010)

Maturity. weight-at-age in the stock, weight-at-age in the catch, F and M before spawning were considered the same as the one considered in the VPA.

For the projections, the mean F (F_{bar} ages 0-2) calculated as the average of the last 2 years for each age class was used and defined as F status quo (F_{stq} = 0.56). Several scenarios with constant harvest strategy were run.

Stock recruitment

The recruitment (age 0+) used for the short term projection derived from the geometric mean (2009-2010) of the stock numbers provided by the VIT.

7.20.1.3 Results

A short term projection (Table 7.20.1.3.1), assuming an F_{stq} of 0.56 and a recruitment of 7.4 (millions) individuals, shows that:

- Fishing at the F_{stq} (0.56) in the time frame from the year 2010 to 2012 generates an increase of the catch for 47 % in 2011 and an increase of the spawning stock biomass for 45 % from the year 2012 to 2013.
- Fishing at $F_{0.1}$ (0.27) for the same time frame (2011-2013) generates a decrease of the catch for 21 % in 2012 and an increase of the spawning stock biomass of 92 % from the year 2012 to 2013.
- A 20% reduction of the F_{stq} (F from 0.56 to 0.45) generates an increase of catch for 23 % in 2012 and of spawning stock biomass for 61.0 % from the year 2012 to 2013.

The last point clearly indicates that the 20% reduction of F generates a big increase (61%) in the SSB from the year 2012 to 2013. To obtain a greater increase of SSB as well as a small increase of catch for the 2012 the reduction of F should be of 30 %.

EWG 11-20 recommends the catch in 2011 should not exceed the catch of 20 tons that corresponds to $F_{0.1}$.

Outlook until 2013

Table 7.20.1.3.1. Short term forecast in different F scenarios computed for hake in GSA 11.

Basis: F(2011) = mean F (F_{bar} ages 0-2); R(2011) = mean(2009–2010) = 7.4 (millions); F(2011) = 0.56; SSB (2011) = 99 t; Catch (2011) = 31 t. Weights in tons.

Rationale	F scenario	F factor	Catch 2012	Catch 2013	SSB 2013	Change SSB 2012-2013 (%)	Change Catch 2010-2012 (%)
zero catch	0.00	0	0	0	243	153	-100
High long-term yield ($F_{0.1}$)	0.27	0.48	20	31	196	92	-21
Status quo	0.56	1	38	45	159	45	47
Different scenarios	0.06	0.1	5	9	232	139	-82
	0.11	0.2	9	16	221	125	-65
	0.17	0.3	13	22	212	113	-48
	0.22	0.4	17	27	203	101	-33
	0.28	0.5	21	31	194	90	-18
	0.34	0.6	25	35	186	80	-4
	0.39	0.7	28	38	178	70	10
	0.45	0.8	31	41	171	61	23
	0.51	0.9	35	43	165	53	36
	0.62	1.1	41	46	153	38	59
	0.67	1.2	43	47	147	31	70
	0.73	1.3	46	48	142	24	80
	0.79	1.4	49	49	137	18	91
	0.84	1.5	51	49	133	12	100
	0.90	1.6	54	50	129	7	110
	0.96	1.7	56	50	124	2	119
	1.01	1.8	58	50	121	-3	127
	1.07	1.9	60	50	117	-7	136
	1.12	2	62	50	114	-12	144

7.21 Red mullet (*Mullus barbatus*) in GSA 11

7.21.1 Short term prediction 2011-2013

7.21.1.1 Method and justification

Short term prediction for 2010-2012 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the stock assessment performed using VIT (Lleonart and Salat, 1997) that was conducted in the framework of the EWG 11-12 and EWG 11-20 meetings.

7.21.1.2 Input parameters

The following data have been used to derive the input data for the short term projection of the red mullet in GSA 11:

Maturity and M vectors

PERIOD	Age	0	1	2	3
2006-2010	Prop. Matures	0	1	1	1

PERIOD	Age	0	1	2	3
2006-2010	M	1.30	0.41	0.27	0.23

F vector

F	0	1	2	3
2006	0.186	2.201	1.507	0.6
2007	0.098	2.01	1.663	0.6
2008	0.836	2.912	0.6	
2009	0.121	1.655	2.038	0.6
2010	0.063	1.13	2.257	0.6
2011*	0.24	1.80	1.47	0.55

* mean of the last three years rescaled to 2010

Weight-at-age in the stock

Mean weight in stock	0	1	2	3
Kg	0.010	0.044	0.091	0.135

Weight-at-age in the catch

Mean weight in stock	0	1	2	3
Kg	0.010	0.044	0.091	0.135

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2	3
2006	3663	6306	418	41
2007	2319	7764	671	54
2008	15617	4250	73	
2009	1724	4259	614	31
2010	727	2946	900	36

Number at age in the stock

Stock at age in numbers (thousands)	0	1	2	3
2006	41065	8489	624	106
2007	60305	13617	1211	175
2008	55461	5986	216	
2009	31327	6912	876	87
2010	23126	5408	1159	93
2011*	34251	6071	603	90

* Geometric mean

Maturity. weight-at-age in the stock, weight-at-age in the catch, F and M before spawning were considered the same as the one considered in the VPA.

For the projections, the mean F (F_{bar} ages 0-3) calculated as the average of the last 3 years for each age class was used and defined as F status quo (F_{stq} = 1.19). Several scenarios of constant harvest strategy were run.

Stock recruitment

The recruitment (age 0+) used for the short term projection derived from the geometric mean of the stock numbers provided by the VIT.

7.21.1.3 Results

A short term projection (Table 7.21.1.3.1), assuming an F_{stq} of 1.19 and a recruitment of 39.5 (millions) individuals, shows that:

- Fishing at the F_{stq} (1.19) in the time frame from the year 2010 to 2012 generates an increase of the catch for 35 % in 2011 and a least increase of the spawning stock biomass for 1 % from the year 2012 to 2013.

- Fishing at $F_{0.1}$ (0.26) for the same time frame (2011-2013) generates a decrease of the catch for 51 % in 2012 and an increase of the spawning stock biomass of 53 % from the year 2012 to 2013.

- A 20% reduction of the F_{stq} (F from 1.19 to 0.95) generates an increase of catch for 21 % in 2012 and of spawning stock biomass for 16.0 % from the year 2012 to 2013.

The last point clearly indicates that the 20% reduction of F generates a small increase (16%) in the SSB from the year 2012 to 2013. To obtain a greater increase of SSB as well as a small increase of catch for the 2012 the reduction of F should range from 30 % to 40%.

EWG 11-20 recommends the catch in 2012 should not exceed the catch of 90 tons that corresponds to $F_{0.1}$.

Outlook until 2013

Table 7.21.1.3.1. Short term forecast in different F scenarios computed for red mullet in GSA 11.

Basis: F(2011) = mean F (F_{bar} ages 1-3); R(2011) = mean(2006–2010) = 39.5 (millions); F(2011) = 1.19; SSB (2011) = 312 t; Catch (2011) = 258 t. Weights in tons.

Rationale	F scenario	F factor	Catch 2012	Catch 2013	SSB 2013	Change SSB 2012-2013 (%)	Change Catch 2010-2012 (%)
zero catch	0.00	0	0	0	761	153	-100
High long-term yield ($F_{0.1}$)	0.26	0,22	90	169	594	97	-51
Status quo	1.19	1	250	253	307	1	35
Different scenarios	0.12	0.1	45	96	677	125	-76
	0.24	0.2	84	160	606	101	-55
	0.36	0.3	117	201	546	81	-37
	0.48	0.4	145	227	495	64	-22
	0.59	0.5	169	243	451	49	-9
	0.71	0.6	190	252	413	36	3
	0.83	0.7	208	256	381	25	12
	0.95	0.8	224	257	353	16	21
	1.07	0.9	238	256	328	8	28
	1.31	1.1	261	250	288	-6	41
	1.43	1.2	271	246	272	-11	46
	1.54	1.3	279	243	257	-16	51
	1.66	1.4	287	239	244	-21	55
	1.78	1.5	294	235	232	-25	59
	1.90	1.6	300	231	221	-28	62
	2.02	1.7	306	228	211	-32	65
	2.14	1.8	312	224	202	-35	68
	2.26	1.9	316	221	194	-38	71
	2.38	2	321	218	186	-40	73

7.22 Sardine (*Sardina pilchardus*) in GSA 16

Updated, although still (January 2012) not officially released, information on sardine stock acoustic biomass (echosurvey) in 2011 was used to accomplish short term predictions of sardine catches for 2012.

The application of the regression approach suggested at SGMED 09-03 meeting, aiming at exploring the relationship between the series of acoustic biomass at year (t) and landings at year (t+1) and already performed for short term predictions of sardine stock in GSA16 for 2009 and 2010 (see SGMED-09-03 and SGMED-10-03 reports), was firstly checked and then revisited including in the regression analysis updated (2010 and 2011) information.

The regression analysis had covered the periods 1998-2007 (biomass estimates) and 1999-2008 (landing data) in SGMED-09-03, and the periods 1998-2008 (biomass estimates) and 1999-2009 (landings data) in SGMED-10-03, whereas in the present run available data for the following years of the two series (2009-2010 for biomass and 2010-2011 for landings) were also included in the analysis.

The results of the updating of the regression model are summarized below, together with the results of the previous regression models (see also SGMED-09-03 and SGMED-10-02 reports), reported for comparisons purposes:

Table 7.22.1. Results of the regression model updating.

Model	SGMED/EWG-MED	n	Intercept	slope	F	P	r	r^2
1	09-03	10	1667.63	0.026372	4.09	0.08	0.58	0.34
2	10-03	11	1647.72	0.026930	4.89	0.05	0.59	0.35
3	-	12	1376.90	0.036872	5.30	0.04	0.59	0.35
4	11-20	13	1450.28	0.035875	4.68	0.05	0.55	0.30

The resulting estimated landings are listed in Table 7.22.2.

Table 7.22.2 - Results of the estimated landings.

Year	Estimated landings [tons] (model 1 of Tab. 7.22.1)	Estimated landings [tons] (model 2 of Tab.7.22.1)	Estimated landings [tons] (model 3 of Tab. 7.22.1)	Estimated landings [tons] (model 4 of Tab. 7.22.1)
2009	1,988	1,975	1,825	1,886
2010	1,879	1,864	1,673	1,738
2011	2,057	2,046	1,922	1,980
2012	2,063	2,051	1,929	1,988

The output of the last formulation of model fitting (see model 4 in tables 7.22.1 and 7.22.2) for year 2011 (estimated sardine landings = 1,980 t) was compared with total landings (2,665 t) estimated from Sciacca port census data, showing an underestimation of about 26%.

7.23 Sardine (*Sardina pilchardus*) in GSA 17

7.23.1 Short term prediction 2011-2013

7.23.1.1 Method and justification

Short term predictions were implemented in R (www.r-project.org) using the FLR libraries and based on the results of Virtual Population Analysis (VPA) carried out between 1975-2010 within the framework of the FAO-Adriamed working group and presented at the GFCM-SAC-SCSA Working Group on Small Pelagic species annual meeting held in Chania on October 2011.

7.23.1.2 Input parameters

The following data have been used to derive the input data for the short term projection of the European pilchard stock in GSA17:

Maturity and M vectors

PERIOD	Age	1	2	3	4	5	6+
1975-2010	Prop. Matures	1.0	1.0	1.0	1.0	1.0	1.0

PERIOD	Age	1	2	3	4	5	6+
1975-2010	M	1.10	0.76	0.62	0.56	0.52	0.50

M was calculated using the Gislason's equation using the following growth parameters: L_{inf} = 20.5 cm, k = 0.46 year^{-1}, t0 = 0.5 year^{-1} according to Sinovčić, 1984.

F vector

F	1	2	3	4	5	6+
2010	0.029	0.326	0.762	0.839	1.041	1.041

The F_{bar} was calculated between ages 1 and 4.

Weight-at-age in the catch and in the stock

Mean weight in stock (2008-2010)	1	2	3	4	5	6+
Kg	0.0227	0.0280	0.0327	0.0367	0.0417	0.0473

Number at age in the stock from VPA (thousands)

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6+
2008	8401880	1666350	732310	344750	72170	60680
2009	7971000	2696960	597570	256070	102920	50590
2010	13603400	2583360	990080	79030	30340	1650
2011	9992093*	4399540	872390	248490	19520	6730

** geometric mean*

7.23.1.3 Results

A short term projection (Table 7.23.1.3.1), assuming an F_{stq} of 0.489 in 2011 and a recruitment of about 13 billions individuals, shows that:

- Fishing at the F_{stq} from 2011 to 2012 generates an increase in catch of 8.4% and a decrease of the SSB between 2012 and 2013 of 1.8%.
- Fishing at F_{MSY} (0.51) for the same time frame (2011-2012) generates an increase in the catches of 12% and a decrease of spawning stock biomass of 2.1% from 2012 to 2013.

STECF EWG 11-20 considers the stock being harvested sustainably, as $E_{1\text{-}4}$ between 2008-2010 it's equal to 0.37. Keeping with the present analysis based on F_{stq}, and the use of F_{MSY} as a target reference point, EWG 11-20 reccomends that catch for sardine in the Northern Adriatic Sea (GSA 17) in 2012 should not exceed 47500 t in 2012 and 44500 t in 2013.

Outlook until 2013

Table 7.23.1.3.1. Short term forecast in different F scenarios computed for sardine in GSA 17.

Basis: R(2011) = GM(2008–2010) = 13 (billions); F (2010) = 0.489; Catch (2010) = 33301 t. Weights in tons.

Rationale	F scenario	F factor	Catch 2012	Catch 2013	SSB 2013	Change SSB 2012 -2013 (%)	Change Catch 2010 -2012 (%)
Zero catch	0	0	0	0	406516	7.3	-100%
High long term yield (F_{MSY})	0.51	1.04	47512	44553	370005	-2.1	41.7
Status quo	0.489	1	45970	43582	371142	-1.81	37.1
Different scenarios	0.05	0.1	5660	7203	402027	6.10	-83.12
	0.10	0.2	11040	13508	397790	5.02	-67.08
	0.15	0.3	16160	19042	393788	3.99	-51.81
	0.20	0.4	21036	23913	390006	3.02	-37.27
	0.24	0.5	25684	28215	386427	2.11	-23.41
	0.29	0.6	30118	32027	383038	1.24	-10.18
	0.34	0.7	34351	35415	379826	0.42	2.44
	0.39	0.8	38397	38439	376781	-0.36	14.50
	0.44	0.9	42266	41147	373889	-1.10	26.04
	0.49	1	45970	43582	371142	-1.81	37.09
	0.54	1.1	49518	45780	368531	-2.48	47.67
	0.59	1.2	52921	47773	366045	-3.11	57.82
	0.64	1.3	56186	49587	363678	-3.72	67.55
	0.68	1.4	59322	51245	361421	-4.30	76.91
	0.73	1.5	62336	52768	359267	-4.85	85.90
	0.78	1.6	65236	54171	357211	-5.37	94.54
	0.83	1.7	68028	55471	355246	-5.88	102.87
	0.88	1.8	70718	56679	353367	-6.36	110.89
	0.93	1.9	73311	57807	351568	-6.82	118.63
	0.98	2	75814	58863	349844	-7.26	126.09

F_{MSY} has been calculated in order to have an exploitation rate (E_{1-4}) of 0.4, given M_{1-4}.

7.23.2 Medium term prediction 2011-2020

7.23.2.1 Method and justification

Medium term prediction from 2011 to 2020 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of stock assessment obtained by the means of Laurec-Shepherd VPA. Medium term projections (10 years) were run assuming:

constant F = F_{MSY} since 2011;

progressive changes in F to achieve F_{MSY} in 5 years (2015);

progressive changes in F to achieve F_{MSY} in 10 years (2020).

The stock-recruitment relationship used geometric mean recruitment over the observed SSB range from 1975 to 2010. Recruitment process error was modelled using random numbers sampled from a lognormal distribution with a standard deviation of 0.3.

7.23.2.2 Input parameters

The maturity ogive, the natural mortality, the numbers of individuals and weight-at-age for the stock and for the catch were the same used in the short term forecast.

7.23.2.3 Results

In Figure 7.23.2.3.2, the 25th, 50th, and 75th percentile are showed for the SSB, recruitment and catches in t from 2011 to 2020, considering a constant F = F_{MSY} since 2011.

In Figure 7.23.2.3.3, the 25th, 50th, and 75th percentile are showed for the SSB, recruitment and catches in t from 2011 to 2020, considering an increase of the F_{stq} from 2011 to 2015, to reach F_{MSY} in 2015, and then a constant F = F_{MSY} until 2020.

In Figure 7.23.2.3.4, the 25th, 50th, and 75th percentile are showed for the SSB, recruitment and catches in t from 2011 to 2020, considering an increase of the F_{stq} from 2011 to reach F = F_{MSY} in 2020.

Landing data of sardine from 1975 to 2010 in the GSA17 are displayed in Figure 7.23.2.3.1. The landings of this species reached their maximum in the early 1981 with more than 90000 t, and then constantly decreased until

2005, when they start recovering.

Since the F_{stq} value is almost equal to the target F_{MSY},, there are no differences between the various scenarios.

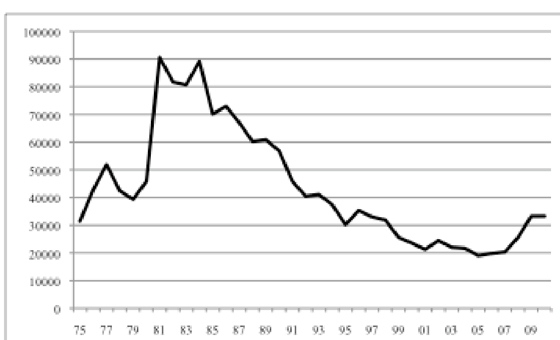


Fig. 7.23.2.3.1. Landings of sardine in the GSA 17 (in tons).

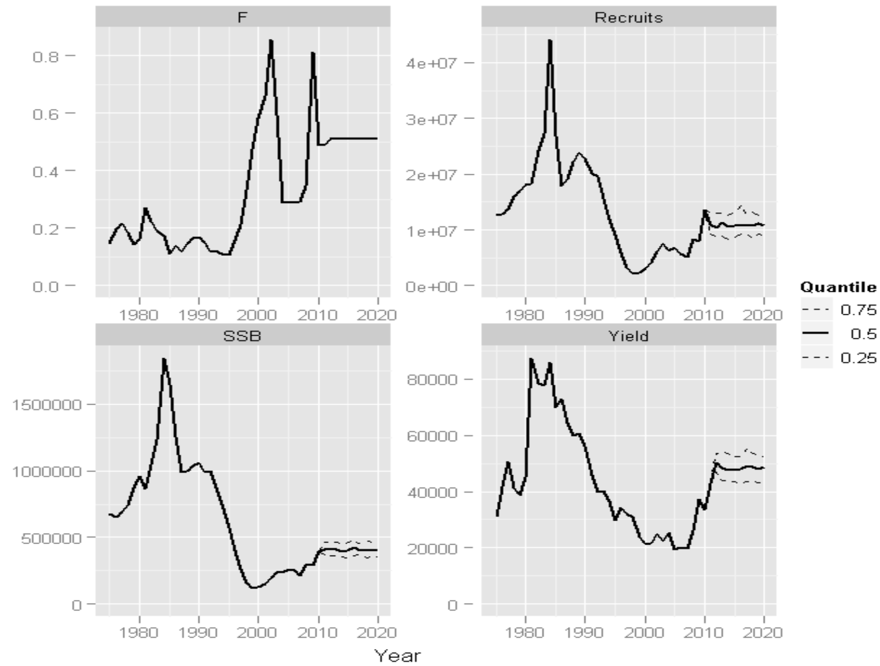


Fig. 7.23.2.3.2. Output of the medium term forecast computed for sardine in the GSA 17 achieving F_{MSY} in 2011.

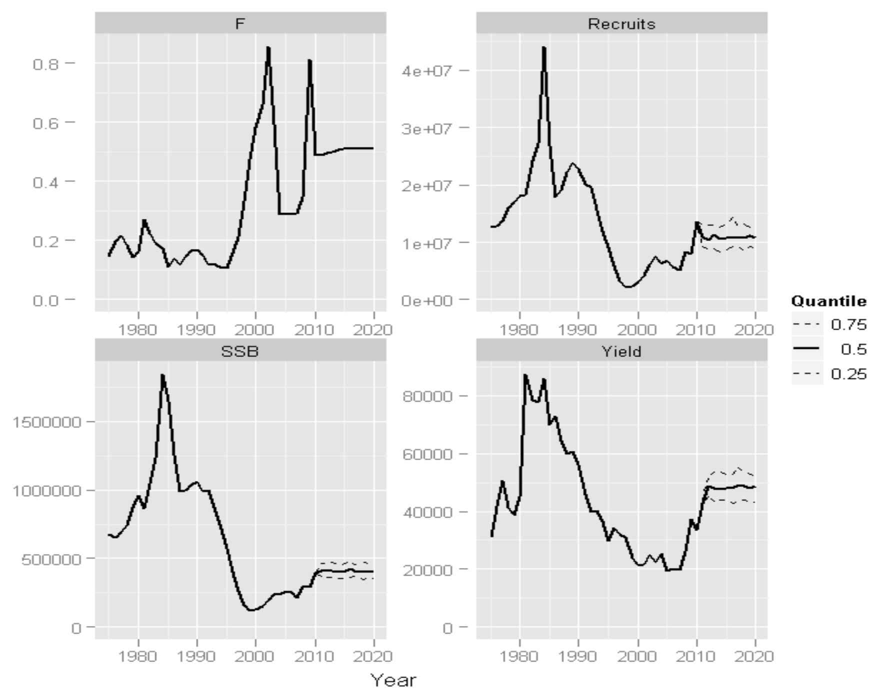


Fig. 7.23.2.3.3. Output of the medium term forecast computed for sardine in the GSA 17 achieving F_{MSY} in 2015.

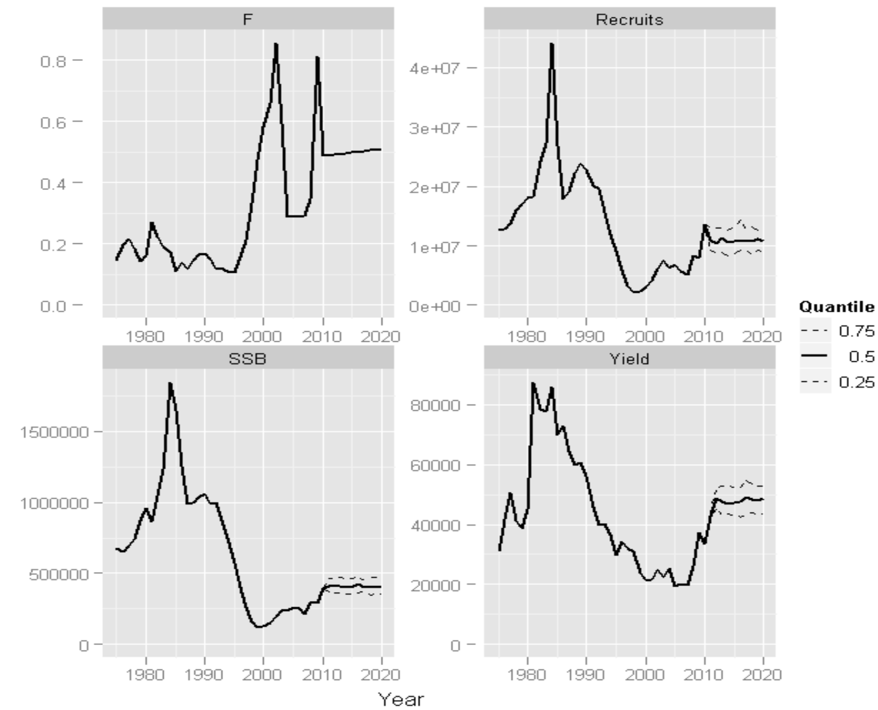


Fig. 7.23.2.3.4. Output of the medium term forecast computed for sardine in the GSA 17 achieving F_{MSY} in 2020.

7.24 Common sole (*Solea solea*) in GSA 17

7.24.1 Short term prediction 2011-2013

7.24.1.1 Method and justification

Short term prediction from 2011 to 2013 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) stock assessment that was conducted in the framework of the EWG 11-12 using the VPA Lowestoft software suite. The input data of the XSA results considered in the present analyses were Italian, Croatian and Slovenian catch at age data series of the period 2005-2009, coming from the SoleMon project and utilized in the previous assessments carried in the framework of the SGMED meetings. The data series mentioned was extended in 2010 with data provided by 2011 Slovenian and Italian DCF official statistics.

7.24.1.2 Input parameters

The following data have been used to derive the input data for the short term projection of the common sole in GSA 17:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4	5+
2005-2010	Prop. Matures	0	0.16	0.76	0.96	0.99	1

PERIOD	Age	0	1	2	3	4	5+	Mean 0-4
2005-2010	M	0.7	0.35	0.28	0.25	0.23	0.22	0.40

F vector

F	0	1	2	3	4	5+
2005	0.07	1.75	2.44	1.58	1.49	1.49
2006	0.10	1.84	1.78	1.20	1.25	1.25
2007	0.11	1.57	1.86	1.30	1.23	1.23
2008	0.19	1.49	1.93	1.29	1.24	1.24
2009	0.30	2.66	1.08	1.57	1.42	1.42
2010	0.16	1.91	1.85	1.41	1.35	1.35

Weight-at-age in the stock

Mean weight in stock	0	1	2	3	4	5+
Kg	0.024	0.104	0.207	0.304	0.38	0.522

Weight-at-age in the catch

Mean weight in catch	0	1	2	3	4	5+
Kg	0.024	0.104	0.207	0.304	0.38	0.522

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2	3	4	5+
2005	2190	12910	3120	138	11	8
2006	2629	15151	1637	159	20	10
2007	3813	11205	1768	186	38	14
2008	5779	15675	1830	181	39	14
2009	4957	15195	2191	190	41	21
2010	5614	7124	706	655	29	10

Number at age in the stock

Stock at age in numbers (thousands)	0	1	2	3	4	5+
2005	46334	18595	3930	197	16	11
2006	37653	21466	2266	258	31	15
2007	53925	16845	2408	290	60	22
2008	47404	24091	2464	283	62	21
2009	27095	19467	3818	272	61	30
2010	54427	9962	963	981	44	15
2011	41195*	23072	1040	114	186	12
* geometric mean 2008-2010						

Maturity, weight-at-age in the stock and weight-at-age in the catch were estimated as the mean of the last 3 years. Different scenarios of constant harvest strategy with variation of the mean F (F_{bar} ages 0-4), calculated as the average of the last 3 years, were tested. No particular tren in F in the last years has been observed.

Stock recruitment

The recruitment used for the short term projection was estimated as the geometric mean from 2008-2010. The 2011 SoleMon survey data were not available during the meeting because the survey has been conducted at the end of November 2011.

7.24.1.3 Results

A short term projection (Table 7.24.1.3.1), assuming an F_{stq} of 1.32 in 2011 and a recruitment of 41,195 (thousand) individuals, shows that:

- Fishing at the F_{stq} (1.32) in the time frame from the year 2011 to 2012 generates an increase of the catch for 49 % and a decrease of the spawning stock biomass for 10% from the year 2012 to 2013.
- Fishing at F_{MSY} (0.26) for the same time frame (2011-2012) generates a decrease of the catch for 49 % and a spawning stock biomass increase of 203% from the year 2012 to 2013.
- A 30% reduction of the F_{stq} (F = 0.93) generates an increase of catch of 26% and an increase of spawning stock biomass of 37% from the year 2012 to 2013.

In order to reach the target point (F_{MSY}), a decrease of F_{stq} by 80% is needed. Keeping with the present analysis based on F_{stq}, and the use of F_{MSY} as a target reference point, EWG 11-20 deems that catch for sole in the Northern Adriatic Sea (GSA 17) in 2012 should not exceed 632 t, and 1079 t in 2013.

Outlook for 2011-2013

Table 7.24.1.3.1. Short term forecast in different F scenarios computed for common sole in GSA 17.

Basis: Fstq = mean (Fbar2008–2010); R(2011) = GM(2008–2010) = 41,195; F(2011) = 1.32; SSB(2011) = 657 t; SSB(2012) = 695 t; Catch (2011) = 2219 t. Weights in tons.

Rationale	F scenario	F factor	Catch 2012	Catch 2013	SSB 2013	Change SSB 2012-2013 (%)	Change Catch 2010-2012 (%)
zero catch	0	0	0	0	2726	323	-100
High long-term yield ($F_{0.1}$)	0.26	0.2	632	1079	1967	203	-49
Status quo	1.32	1	1845	1778	634	-10	49
Different scenarios	0.13	0.1	348	654	2304	256	-72
	0.26	0.2	641	1092	1955	201	-48
	0.4	0.3	889	1380	1666	155	-28
	0.53	0.4	1098	1565	1427	117	-11
	0.66	0.5	1276	1679	1228	85	3
	0.79	0.6	1427	1746	1062	59	15
	0.93	0.7	1556	1779	924	37	26
	1.06	0.8	1667	1791	810	18	35
	1.19	0.9	1762	1789	714	3	42
	1.46	1.1	1917	1761	566	-20	55
	1.59	1.2	1979	1741	510	-29	60
	1.72	1.3	2034	1719	462	-37	64
	1.85	1.4	2083	1697	422	-43	68
	1.99	1.5	2127	1674	388	-49	72
	2.12	1.6	2165	1652	359	-54	75
	2.25	1.7	2200	1631	334	-57	78
	2.38	1.8	2232	1610	312	-61	80
	2.52	1.9	2260	1590	294	-64	83
	2.65	2	2287	1571	278	-66	85

The actual landings recorded in 2010 (1672 t for the Italian, Slovenian and Croatian fleet combined) are lower compared to the landings projected for 2010 by SGMED 10-03 (2140). Such discrepancy, is probably related to the decrease of the Italian nominal effort of TBB and GNS from 2009 to 2010 (see report STECF EWG 11-12).

7.24.2 Medium term prediction

7.24.2.1 Method and justification

Medium term prediction from 2010 to 2020 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) used for the short term forecasts. The program used in the medium term projections (10 years) were assuming a decreasing trend of the F_{stq} toward the F_{MSY} in 10 years, 5 years, 1 year (2012) and a decrease of 10% each year as suggested by the recomendation of FAO-GFCM for the bottom trawling, that is the major fishery targeting this stock. The stock-recruitment relationship used geometric mean recruitment over the observed SSB range from 2008 to 2010. Runs were made with 500 simulations per run to try projecting with stochastic recruitment, multiplying the recruitment by log-normally distributed noise with a mean of 1 and a standard deviation of 0.3.

7.24.2.2 Input parameters

The maturity ogive, the natural mortality, the numbers of individuals and weight-at-age for the stock and for the catch were the same used in the short term forecast.

7.24.2.3 Results

In figure. 7.24.2.3.1, the 25th, 50th, and 75th percentile are showed for the SSB, recruitment and catches in t from 2005 to 2020, considering a constant reduction of the F_{stq} toward F_{MSY} (around 28% each year) from 2010 to 2015.

In figure. 7.24.2.3.2, the 25th, 50th, and 75th percentile are showed for the SSB, recruitment and catches in t from 2005 to 2020, considering a constant reduction of the F_{stq} toward F_{MSY} (around 14% each year) from 2010 to 2020.

It is interesting that the decreasing fishing mortality determine in both cases a clear increase of the SSB not affecting the amount of the catches in a medium term.

At the moment the fishing activity is conducted in a not rationale sense, considering that the catches could be constant in the medium term with a large decreasing of the fishing mortality.

In figure 7.24.2.3.3, the 25th, 50th, and 75th percentile are showed for the SSB, recruitment and catches in t from 2005 to 2020, considering a reduction of the F_{stq} toward F_{MSY} in 2012.

In figure 7.24.2.3.4, the 25th, 50th, and 75th percentile are showed for the SSB, recruitment and catches in t from 2005 to 2020, considering a constant reduction of the F_{stq} of 10% each year.

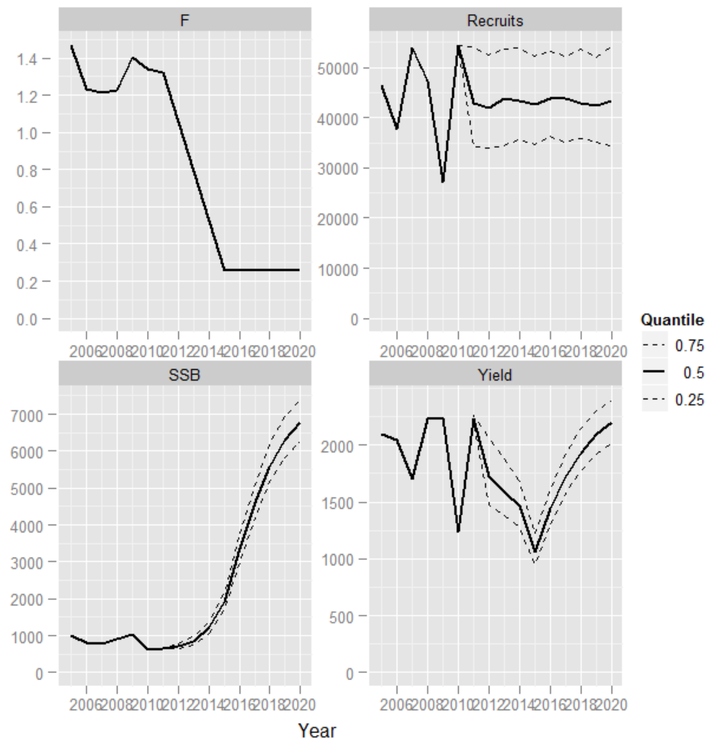


Fig. 7.24.2.3.1. Outputs of the medium term forecast computed for the common sole in GSA 17 reaching the F_{MSY} in 2015.

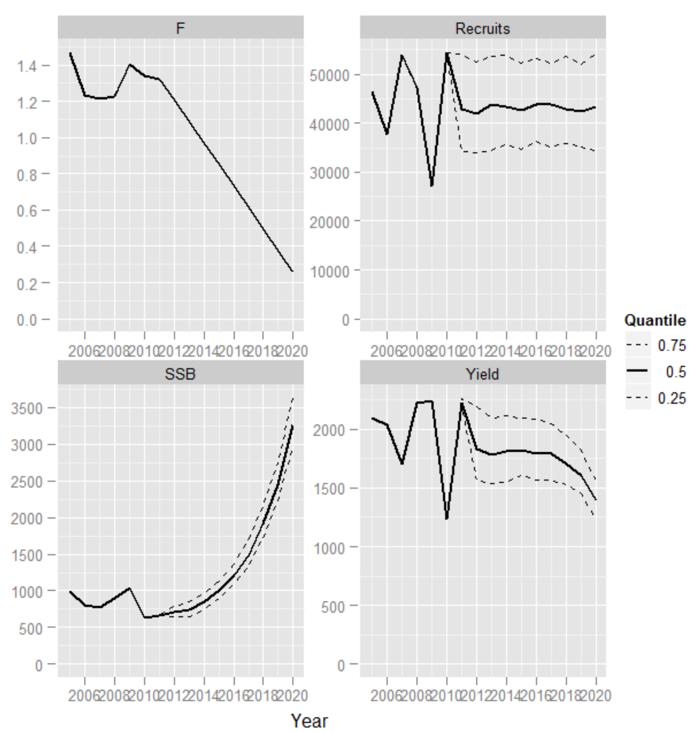


Fig. 7.24.2.3.2. Outputs of the medium term forecast computed for the common sole in GSA 17 reaching the F_{MSY} in 2020.

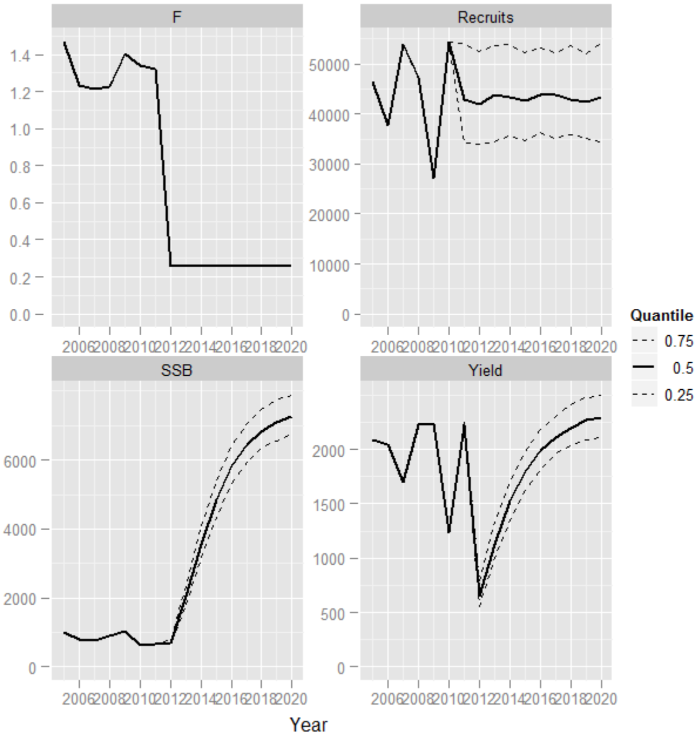


Fig. 7.24.2.3.3. Outputs of the medium term forecast computed for the common sole in GSA 17 reaching the F_{MSY} in 2012.

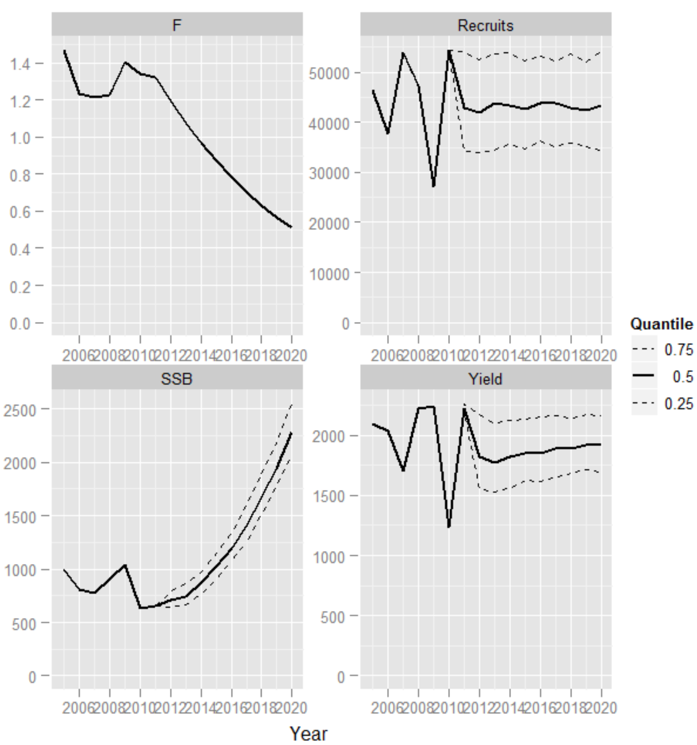


Fig. 7.24.2.3.4. Outputs of the medium term forecast computed for the common sole in GSA 17 decreasing the F_{stq} of 10% each year.

7.25 European hake (*Merluccius merluccius*) in GSA 18

7.25.1 Short term prediction 2011-2013

7.25.1.1 Method and justification

Short term prediction for 2011 -2013 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the stock assessment performed using VIT (Lleonart and Salat, 1997) that was conducted in the framework of the EWG 11-20 using the VPA Lowestoft routines.

7.25.1.2 Input parameters

The input parameters were derived using VIT software. The structure of catches for 2009 and 2008 for the eastern side of the GSA were derived rising the age distribution from the western side to the Albanian catches and considering for 2008 and 2009 an equal catch level and catch structure as in 2010.

The following data have been used to derive the input data for the short term projection of the hake in the GSA 18:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4+
2008-2010	Prop. Matures	0.01	0.12	0.92	1.00	1.00

PERIOD	Age	0	1	2	3	4+	Mean 0-4
2008-2010	M	1.16	0.52	0.40	0.34	0.31	0.55

F vector

F	0	1	2	3	4+
2008	0.248	2.280	0.646	0.465	0.320
2009	0.288	2.327	0.820	0.286	0.320
2010	0.391	1.957	0.705	0.408	0.320
2011*	0.325	2.080	0.702	0.354	0.298

* geometric mean of the last three years rescaled to 2010

Several scenarios with different harvest strategy were run, with F_{stq} (F_{bar} ages 0-3) calculated as the geometric mean of the last 3 years, but rescaled to the F of 2010 (F_{stq} =0.87).

Potential changes in selectivity due to the implementation of the 40mm square/50mm diamond mesh size on trawlers based on EC 1967/2006 were not taken into account in the predictions presented below.

Weight-at-age in the stock

Mean weight in stock	0	1	2	3	4+
kg	0.008	0.112	0.503	1.124	2.882

Weight-at-age in the catch

Mean weight in catch	0	1	2	3	4+
kg	0.008	0.112	0.503	1.124	2.882

Number at age in the catch

Catch at age in numbers (thousands)	0	1	2	3	4+
2010	29725	22981	1138	254	212

Number at age in the stock

Stock at age in numbers (thousands)	0	1	2	3	4+
2010	149487	31756	2668	884	418
2011	156555	33920	2359	886	669

Stock recruitment

The recruitment used for the short term projection was estimated as the geometric mean from 2008-2010.

7.25.1.3 Results

A short term projection (Table 7.25.1.3.1), assuming an F_{stq} of 0.87 in 2011 and a recruitment of 156,555 (thousands) individuals, shows that:

- Fishing at the F_{stq} (0.87) from 2011 to 2012 generates an increase of the catch for 4% and an increasing of the spawning stock biomass of 4% from 2012 to 2013.
- Fishing at $F_{0.1}$ (0.21) for the same time (2011-2012) generates a decrease of the catch of 60% and a spawning

stock biomass increase of 130% from 2012 to 2013.

- A 30% reduction of the F_{stq} (F=0.61) generates a decrease of catch for 15% and an increase of spawning stock biomass of about 36% from 2012 to 2013, indicating that this level of reduction could generate a decrease of catches but a significant increase of the spawning stock biomass.

EWG 11-20 recommends that fishing mortality in 2012 should not exceed $F_{0.1}$= 0.21, corresponding to catches of 1,674 tons.

Outlook until 2013

Table 7.25.1.3.1. Short term forecast in different F scenarios computed for hake in GSA 18.

Basis: F (2011) = F (2010) rescaled (F_{bar} 0-3); R (2010) = GM (2008–2010) = 156,555 (thousands); F (2011) =0.87; SSB (2011) = 4625; Catch (2011) = 4202 t. Weights in tons.

Rationale	F scenario	F factor	Catch 2012	Catch 2013	SSB 2013	Change SSB 2012-2013 (%)	Change Catch 2010-2012 (%)
Zero catch	0.00	0.00	0	0	15695	222.60	-100.00
High long-term yield ($F_{0.1}$)	0.21	0.24	1674	2786	11208	130.37	-60.78
Status quo	0.87	1.00	4428	4484	5049	3.78	3.75
Different scenarios	0.09	0.10	765	1425	13597	179.48	-82.08
	0.17	0.20	1422	2446	11858	143.73	-66.69
	0.26	0.30	1989	3170	10411	114.00	-53.40
	0.35	0.40	2481	3673	9205	89.20	-41.86
	0.43	0.50	2911	4016	8194	68.42	-31.78
	0.52	0.60	3290	4240	7344	50.95	-22.93
	0.61	0.70	3624	4379	6626	36.19	-15.09
	0.69	0.80	3922	4455	6016	23.66	-8.12
	0.78	0.90	4188	4486	5496	12.96	-1.87
	0.95	1.10	4646	4460	4663	-4.16	8.85
	1.04	1.20	4844	4418	4327	-11.05	13.50
	1.12	1.30	5026	4366	4034	-17.09	17.76
	1.21	1.40	5193	4306	3775	-22.40	21.68
	1.30	1.50	5348	4240	3546	-27.11	25.31
	1.38	1.60	5493	4171	3342	-31.31	28.69
	1.47	1.70	5627	4100	3158	-35.09	31.84
	1.56	1.80	5753	4027	2992	-38.50	34.79
	1.64	1.90	5871	3955	2841	-41.60	37.57
	1.73	2.00	5983	3882	2703	-44.43	40.18

Respect to the previous short term forecasts (SGMED 10-03) the observed production for 2010 only for Italy was 4020 tons, while the predicted catch (only for Italy) was 3871 tons. The difference between the 2 values (about 4%) is probably due to the assumption made for fishing mortality in 2010, in fact 0.94 was the value of F hypothesized in the forecast for 2010 that is higher than the value estimated by VIT for 2010 (0.87).

7.25.2 Medium term prediction

7.25.2.1 Method and justification

Medium term prediction from 2011 to 2020 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of stock assessment obtained using VIT (Lleonart and Salat, 1997) and the VPA Lowestoft routines. The medium term projections (20 years) were run simulating 4 management scenarios assuming:

- a progressive decreasing trend of F toward $F_{0.1}$ until 2020 (annual reduction of 15%)
- a progressive decreasing trend of F toward $F_{0.1}$ until 2015 (annual reduction of 30%)
- a sharp decreasing to $F_{0.1}$ level from 2012 (75 % of reduction in 2012)
- an annual decrease of 10% until 2020 (F(2020) = 0.335)

Runs were made with 500 simulations per run. To simulate a stochastic process the recruitment was multiplied by log-normally distributed noise with mean 1 and standard deviation 0.3.

7.25.2.2 Input parameters

The maturity ogive, the natural mortality, the numbers of individuals and weight-at-age for the stock and for the catch were the same used in the short term forecast. Potential changes in selectivity due to the implementation of the 40mm square/50mm diamond mesh size on trawlers based on EC 1967/2006 were not taken into account in the predictions made below.

7.25.2.3 Results

In Fig. 7.25.2.3.1 (a), 7.25.2.3.1 (b), 7.25.2.3.2 (c) and 7.25.2.3.2 (d) the 5th, 25th, 50th, 75th and 95th percentile are showed for the SSB, recruitment and catches in t from 2010 to 2020, for the 4 scenarios.

Landing data of hake from 2004 to 2009 in the GSA18 are reported in the table 7.25.2.3.1 and show a rather stable pattern in the last three years after the decreasing following the peak of 5770 tons in 2006. In all the 4 scenarios of the medium-term forecasts the decreasing of fishing mortality results in a clear increase of both SSB and catches in the medium term as well. In the scenario with a sharp decrease of F towards F0.1 the catch reduction is remarkable compared to the other ones. In the scenario reducing fishing mortality of 10% by year the final value of F is 0.33 in 2020.

Table 7.25.2.3.1. Landings of hake in the whole GSA 18.

year	2004	2005	2006	2007	2008	2009	2010
DCF landings	3205	3784	5770	4430	4498	4390	4296

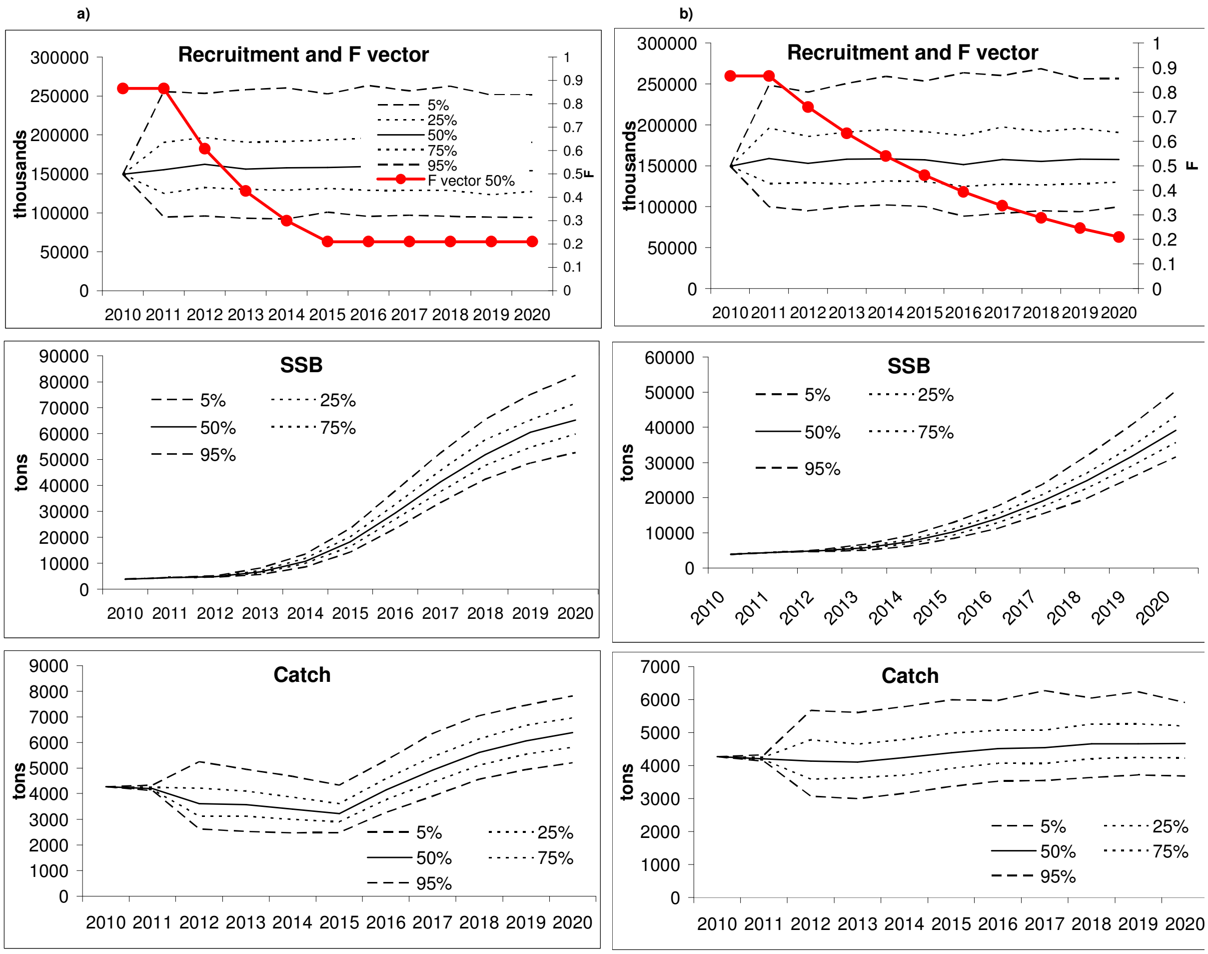


Fig. 7.25.2.3.1. Output of the medium term forecast computed for the hake in the GSA 18 reaching $F_{0.1}$ in 2015 (a) and 2020 (b).

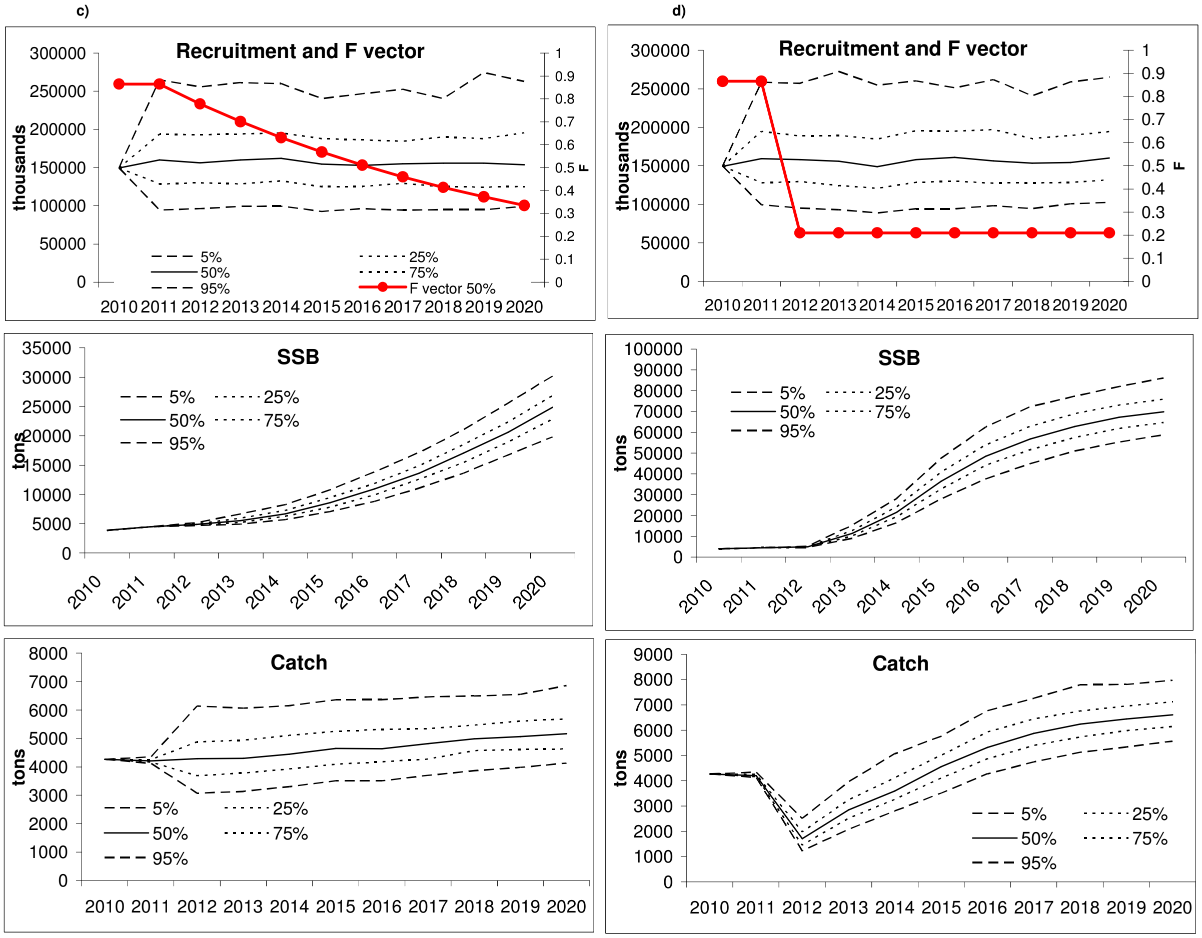


Fig. 7.25.2.3.2. Output of the medium term forecast computed for the hake in the GSA 18 with F decreasing 10% per year until 2020 (c) and with F = $F_{0.1}$ from 2012 to 2020 (d).

7.26 Sardine (*Sardina pilchardus*) in GSA 22

7.26.1 Short term prediction

7.26.1.1 Method and justification

No short term scenario was applied since last year of available data is 2008 and short prediction would refer to 2009 and 2010. A short term scenario has been applied in SGMED 03-09.

7.26.2 Medium term prediction 2015-2020

7.26.2.1 Method and justification

Medium term prediction for 2015 and 2020 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Extended Survivors Analysis (XSA, Darby and Flatman 1994) stock assessment that was applied for sardine stock in GSA 22 in the framework of the STECF-EWG 11-20 using the FLXSA FLR library. The medium term projections (up to 2015 and 2020) assumed a reduction in the F towards the F_{MSY}(E=0.4) by 2015 and by 2020 respectively. The stock-recruitment relationship used was based on the geometric mean for the entire time series available from 2000 to 2008 adding stochasticity in recruitment estimates based on a standard deviation of 0.25. Runs were made with 500 simulations per run.

7.26.2.2 Input parameters

The following input parameters have been used for the short projection of the sardine stock in GSA 22:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4
2000-2008	Prop. Matures	0	0.4	1.0	1.0	1.0

PERIOD	Age	0	1	2	3	4
2000-2008	M	1.5	0.96	0.69	0.61	0.57

F vector

F	0	1	2	3	4
2000	0.003	0.654	1.142	0.620	0.620
2001	0.013	0.956	1.437	0.833	0.833
2002	0.020	0.785	0.781	0.546	0.546
2003	0.008	0.487	0.809	0.323	0.323
2004	0.007	0.424	0.524	0.380	0.380
2005	0.002	0.685	1.114	0.602	0.602
2006	0.006	0.839	1.138	0.591	0.591
2007	0.004	0.559	0.990	0.518	0.518
2008	0.007	0.556	0.963	0.738	0.738

Weight-at-age in the stock

Mean weight in stock	0	1	2	3	4
kg	0.0055	0.0177	0.021	0.0271	0.0343

Weight-at-age in the catch

Mean weight in catch	0	1	2	3	4
kg	0.0041	0.5214	0.9812	0.958	0.208

Number at age in the catch

Catch at age in numbers (x 1000)	0	1	2	3	4
2000	11667	37520	51717	21500	20239
2001	551371	713226	443184	295889	286649
2002	207846	199767	105728	90330	84203
2003	36580	28760	13667	12886	11966
2004	1624	940	406	505	443
2005	1000	1000	1000	1000	1000
2006	11667	37520	51717	21500	20239
2007	551371	713226	443184	295889	286649
2008	207846	199767	105728	90330	84203

Number at age in the stock

Stock at age in numbers (x 1000)	0	1	2	3	4
2000	8414665	1857221	431073	107383	4552
2001	5979688	1872055	369937	69015	2132
2002	5666954	1316526	275464	44073	1255
2003	6049096	1240039	229853	63287	2403
2004	6157934	1339580	291711	51315	1835
2005	5387440	1364461	335542	86681	3422
2006	5017728	1199181	263260	55229	1895
2007	6347948	1112375	198411	42307	1429
2008	6459115	1410895	243529	36981	1031

Maturity, Weight-at-age in the stock, Weight-at-age in the catch was estimated as the mean of the last 3 years. F and M before spawning was considered the same as the one considered in the XSA. Different scenarios of constant harvest strategy with reduction of the mean F (F_{bar} ages 1-3) calculated on the last 3 years, but scaled to the F_{bar} (age 1-3) of 2008 in order to catch the recent decreasing trend in the fishing mortality pattern.

7.26.2.3 Results

Medium term implications

In the figure 7.26.2.3.1 a medium term projection is presented assuming an F_{stq} of 0.752 remaining at this level from 2009 up to 2011 followed by a reduction at F_{MSY} at 0.503 by 2015 and a recruitment of 6104556 (thousand) individuals. The model foresees a slight reduction (1.2 %) in the catch from 2009 (12931 tons) towards 2015 (12775 tons), along with a small increase in SSB (0.6%) from year 2009 (10283 tons) to 2015 (10343 tons). This is related both to the moderate recruitment assumed as well as the short time period that the reduction in F is applied.

In the figure 7.26.2.3.2 a similar medium term projection scenario is presented assuming an F_{stq} of 0.752 remaining at this level from 2009 up to 2011 followed by a reduction at F0.4 at 0.503 by 2020 and a recruitment of 6104556 (thousand) individuals. The model foresees a 21.8% reduction in the catch from 2009 (12931 tons) towards 2020 (10109 tons), along with an increase in SSB (25%) from year 2009 (10283 tons) to 2020 (12823 tons). This shows that a reduction of the F into sustainable levels seems to be able to benefit the stock in terms of SSB in a long term basis.

The reference point of E(0.4) as suggested by Patterson (1998) and endorsed by STECF EWG 11-20 was used proxy for F_{MSY} in the different exploitation scenarios.

Data discrepancies

This medium term prediction relies on the XSA assessment for sardine in GSA 22 but it is based on data derived from the Greek part of the GSA 22 only. Input concerning the Turkish landings data from GSA 22 concerning both total catches as well as length and age structure of the catches will ensure the reduction of possible bias in the estimates of the current stock assessment.

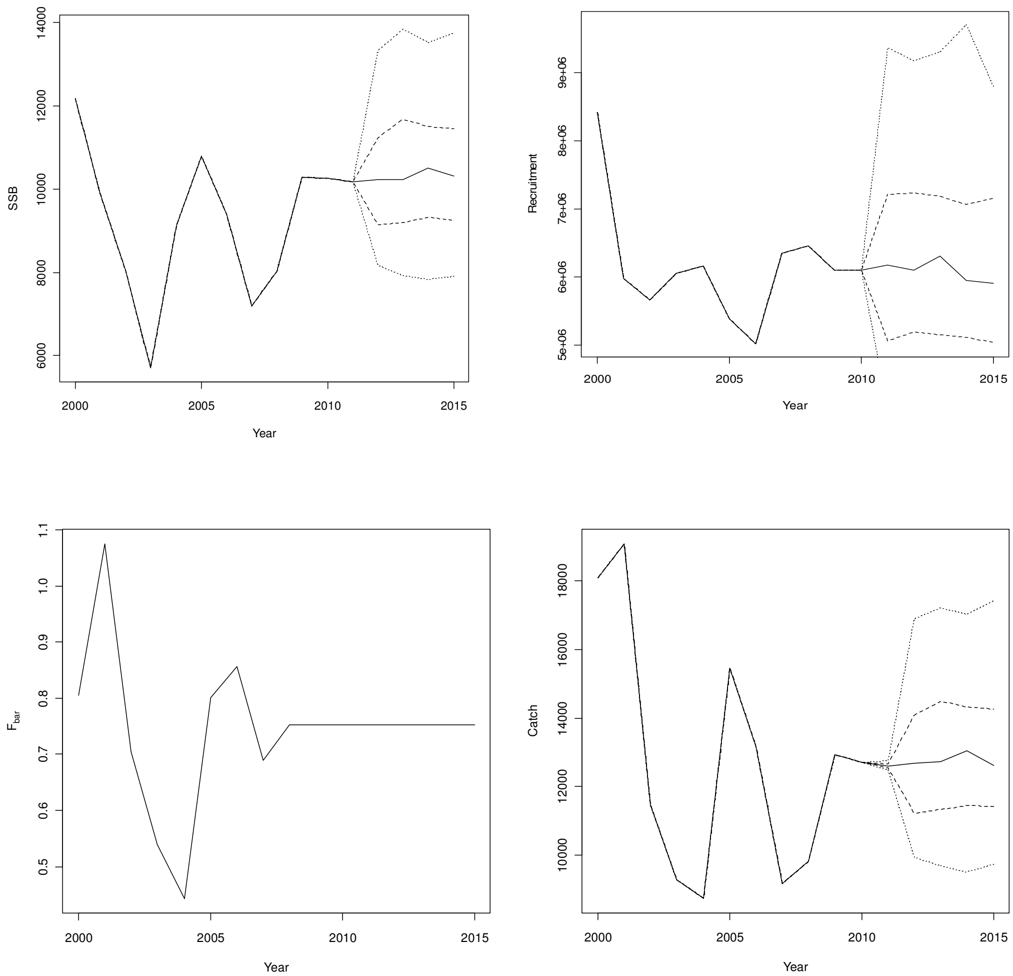


Fig. 7.26.2.3.1. Outputs of the medium term forecast up to 2015 computed for sardine in GSA 22.

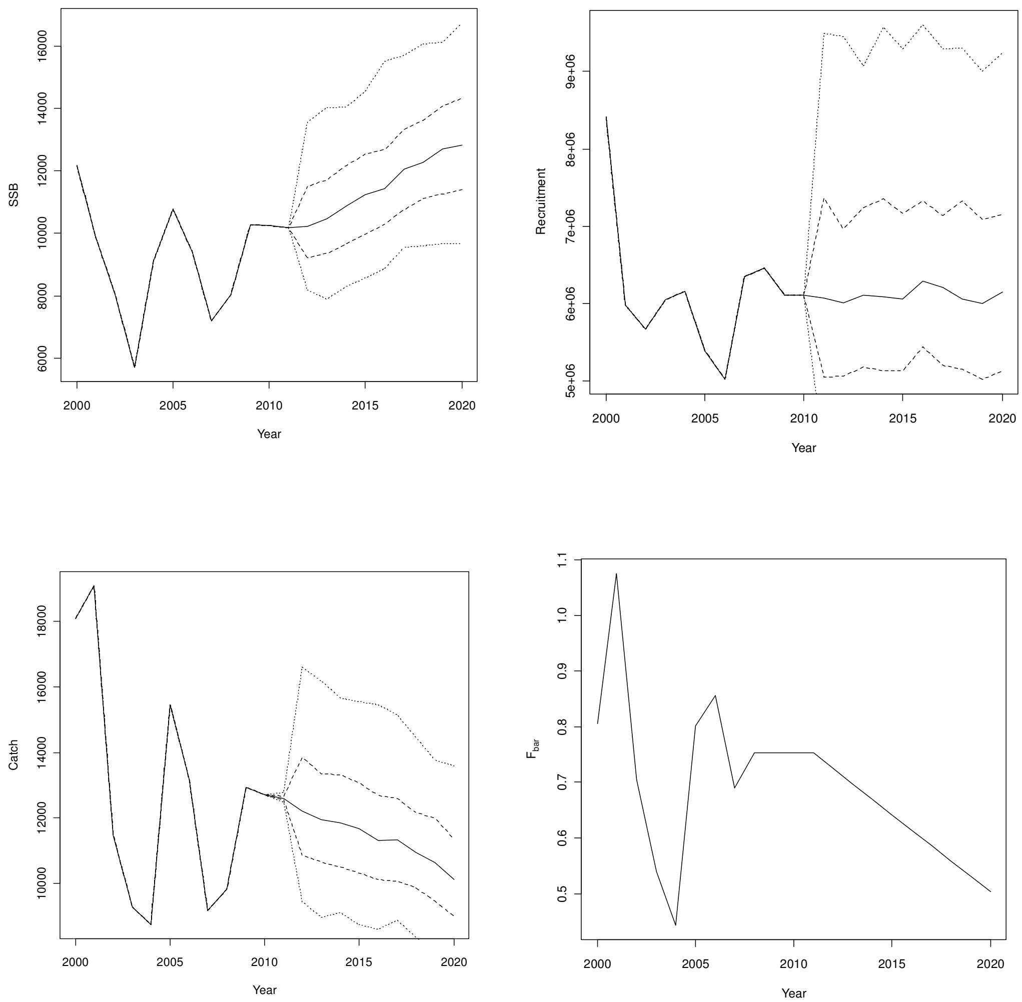


Fig. 7.26.2.3.2. Outputs of the medium term forecast up to 2020 computed for sardine in GSA 22.

7.27 Anchovy (*Engraulis encrasicolus*) in GSA 22

7.27.1 Short term prediction

No short term scenario was applied since last year of available data is 2008 and short prediction would refer to 2009 and 2010. A short term scenario has been applied in SGMED 03-09.

7.27.2 Medium term prediction 2015-2020

7.27.2.1 Method and justification

Medium term prediction for 2015 and 2020 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Extended Survivors Analysis (XSA, Darby and Flatman 1994) stock assessment that was applied for anchovy stock in GSA 22 in the framework of the STECF EWG 11-20 using the FLXSA FLR library. The medium term projections (up to 2015 and 2020) assumed a reduction in the F toward the F(E0.4) by 2015 and by 2020 respectively. The stock-recruitment relationship used was based on the geo,metric mean for the entire time series available from 2000 to 2008. Runs were made with 500 simulations per run to try projecting adding stochasticity in recruitment estimates based on a standard deviation of 0.25.

7.27.2.2 Input parameters

The following input parameters have been used for the medium term projection of the anchovy stock in GSA 22:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4
2000-2008	Prop. Matures	0	0.4	0.98	1.0	1.0

PERIOD	Age	0	1	2	3	4
2000-2008	M	1.5	1	0.74	0.66	0.62

F vector

F	0	1	2	3	4
2000	0.001	0.002	0.001	0.001	0.001
2001	0.229	0.181	0.141	0.180	0.155
2002	1.404	1.006	0.785	0.947	1.214
2003	0.565	0.410	0.319	0.366	0.443
2004	0.565	0.410	0.319	0.366	0.443

2005	0.001	0.002	0.001	0.001	0.001
2006	0.229	0.181	0.141	0.180	0.155
2007	1.404	1.006	0.785	0.947	1.214
2008	0.565	0.410	0.319	0.366	0.443

Weight-at-age in the stock

Mean weight in stock	0	1	2	3	4
kg	0.002	0.008	0.017	0.022	0.023

Weight-at-age in the catch

Mean weight in catch	0	1	2	3	4
kg	0.01	0.014	0.015	0.018	0.022

Number at age in the catch

Catch at age in numbers (x 1000)	0	1	2	3	4
2000	8859	287419	357849	27449	2160
2001	14506	286470	297203	19457	1000
2002	9803	304095	328428	23198	1269
2003	4676	348900	513289	41899	3881
2004	16315	342761	521446	57843	8527
2005	14523	498088	591543	43454	3003
2006	21930	766824	863957	57795	6472
2007	46515	731249	782267	58787	5727
2008	75828	892863	866883	64421	2531

Number at age in the stock

Stock at age in numbers (x 1000)	0	1	2	3	4
2000	12786927	2317282	686847	88480	6633
2001	17067680	2848964	678152	80526	3975
2002	15682110	3801462	874323	118267	6245
2003	17676861	3494521	1214037	190295	16971

2004	24252908	3942032	1073944	224688	31759
2005	26392228	5403849	1242298	152213	10052
2006	27949854	5882042	1685859	184118	19633
2007	39024315	6226096	1698780	207582	19331
2008	38441213	8685530	1846928	270173	10200

Maturity, Weight-at-age in the stock, Weight-at-age in the catch was estimated as the mean of the last 3 years. F and M before spawning was considered the same as the one considered in the XSA. Different scenarios of constant harvest strategy with reduction of the mean F (Fbar ages 1-3) calculated on the last 3 years, but scaled to the F_{bar}(ages 1-3) of 2008 in order to catch the recent decreasing trend in the fishing mortality pattern.

7.27.2.3 Results

In the graphs in figure 7.27.2.3.1, 5th , 25th, 50th, 75th and 95th percentile are showed for the SSB, recruitment and catches in tons from 2000 to 2015, considering a progressive reduction in F_{stq} in order to catch the F_{MSY}(E0.4) in 2015.

The graphs in figure 7.27.2.3.2, 5th , 25th, 50th, 75th and 95th percentile show the SSB, recruitment and catches in tons from 2000 to 2020, also considering a progressive reduction in F_{stq} in order to reach the F_{MSY}(E0.4) in 2020.

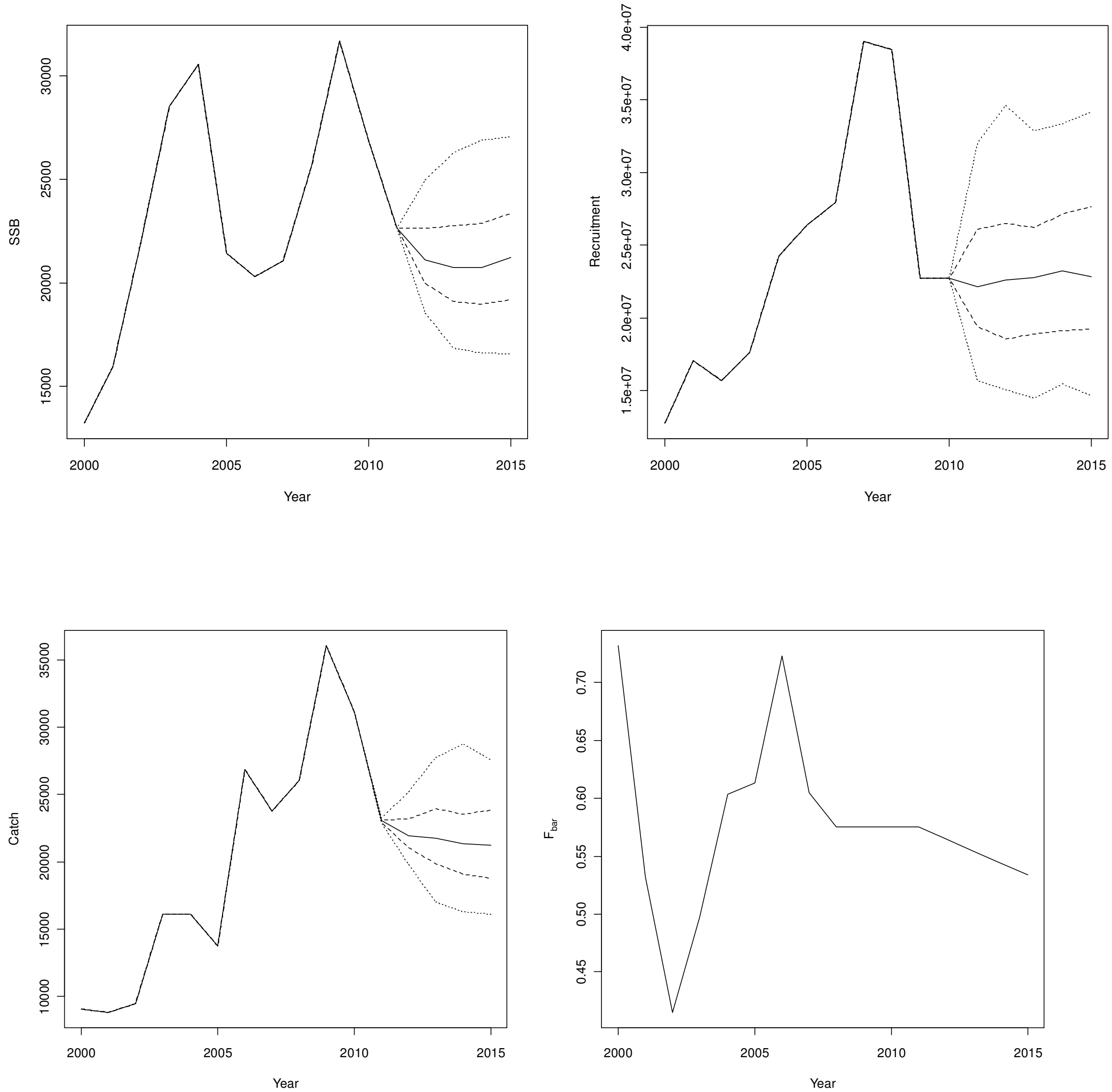


Fig. 7.27.2.3.1. Outputs of the medium term forecast for 2015 computed for anchovy in GSA 22

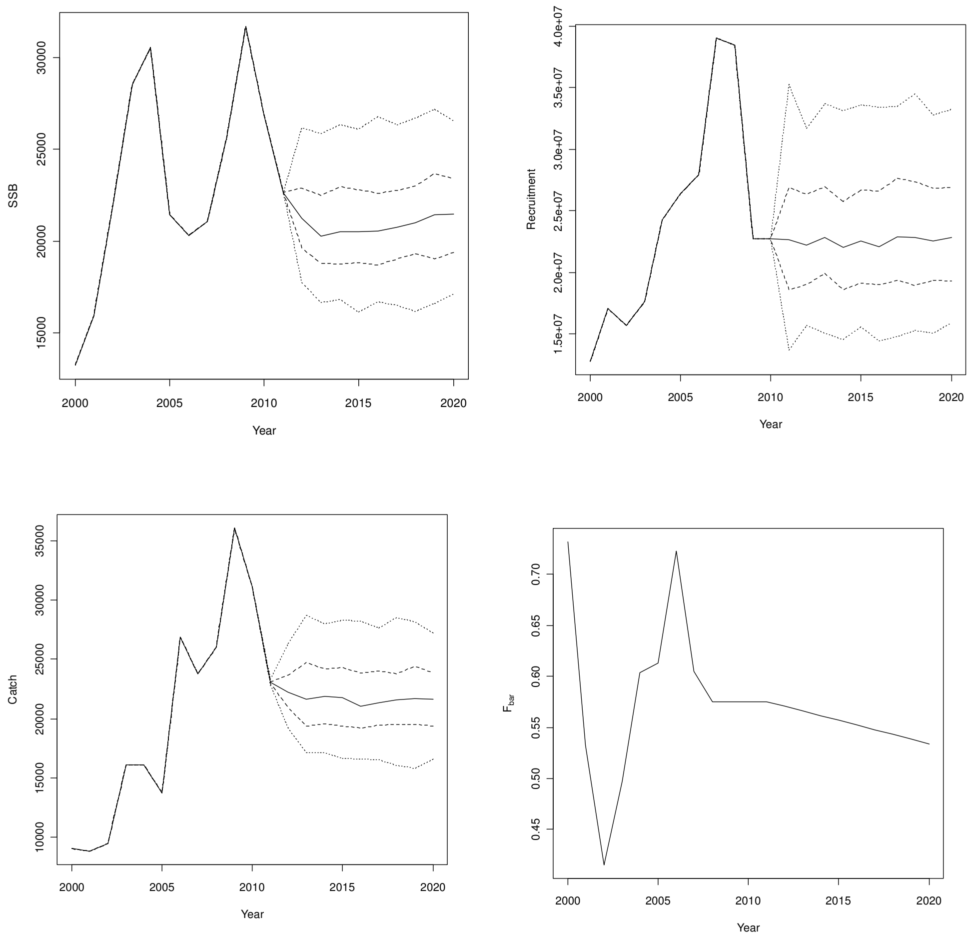


Fig. 7.27.2.3.2. Outputs of the medium term forecast for 2020 computed for anchovy in GSA 22

Medium term implications

In figure 7.27.2.3.1 a medium term projection is presented assuming an Fstq of 0.57 remaining at this level from 2009 up to 2011 followed by a reduction at F0.4 at 0.534 by 2015 and a recruitment of 22736440 (thousand) individuals. It shows that SSB and catch remain generally stable from 2011 to 2015 at a level of 22000 tons. Compared to 2009 situation a decrease by 40% in the catch is foreseen at 2015 along with a decrease in SSB from the year 2009 to 2015 by 33%. However, this reduction is largely related to the low recruitment scenario assumed for the projected time series compared to the high recruitment estimated in 2008 and not the applied F scenario.

Similarly, in the figure 7.27.2.3.2 a medium term projection is presented assuming an F_{stq} of 0.57 remaining at this level from 2009 up to 2011, followed by a progressive reduction at F(E0.4) of 0.534 by 2020 and a recruitment of 22736440 (thousand) individuals. Similarly, it shows that SSB and catch remain generally stable from 2011 to 2020 at a level of 22000 tons in consistency with the fact that the stock seems to be harvested sustainably. The reduction observed in the SSB and the catch compared to 2009 situation is due to the low recruitment scenario assumed for the projected time series compared to the high recruitment estimated in 2008 and not due to the applied F scenario.

The reference point of F_{MSY}(E0.4) as suggested by Patterson (1998) and endorsed by STECF EWG 11-20 was used in order comment the short terms implications of the different exploitation scenarios.

Data discrepancies

This medium term prediction relies on the XSA assessment for anchovy in GSA 22 but it is based on data derived from the Greek part of the GSA 22 only. Input concerning the Turkish landings data from GSA 22 concerning both total catches as well as length and age structure of the catches will ensure the reduction of possible bias in the estimates of the current stock assessment.

7.28 Picarel (*Spicara smaris*) in GSA 25

7.28.1 Short term prediction 2011-2013

7.28.1.1 Method and justification

The assessment performed for this stock during the last FAO-GFCM-SCSA Working Group on Demersal employed a method that require the equilibrium assumption (VPA with VIT software). Although the perception of the stock is quite similar, the results obtained with the VIT model can be affected by the assumption of the steady state, so the group decided to consider the results of the assessment carried out during the EWG 11-12 to perform the forecasts.

Short term prediction from 2011to 2013 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) stock assessment that was conducted in the framework of the STECF EWG 11-12 using the VPA Lowestoft software suite.

7.28.1.2 Input parameters

The following data have been used to derive the input data for the short term projection of picarel in GSA 17:

Maturity and M vectors

PERIOD	Age	0	1	2	3	4 +
2005-2010	Prop. Matures	0.79	0.85	0.90	0.85	0.97

PERIOD	Age	0	1	2	3	4+
2005-2010	M	0.38	0.12	0.08	0.08	0.08

F vector

F	0	1	2	3	4+
2005	0.05	0.14	0.11	0.12	0.12
2006	0.01	0.07	0.14	0.09	0.09
2007	0.00	0.10	0.24	0.12	0.12
2008	0.02	0.11	0.23	0.18	0.18
2009	0.05	0.11	0.13	0.16	0.16
2010	0.02	0.09	0.10	0.10	0.10

Weight-at-age in the stock

Mean weight in stock	0	1	2	3	4+
Kg	0.007	0.012	0.025	0.033	0.04

Weight-at-age in the catch

Mean weight in catch	0	1	2	3	4+
Kg	0.007	0.012	0.025	0.033	0.04

Number at age in the catch

Catch at age in numbers (x 1000)	0	1	2	3	4	5+
2005	2029	4593	3221	1767	1040	8
2006	448	1938	3793	2155	1174	10
2007	162	2581	5046	2567	1111	14
2008	664	2616	4477	2852	1404	14
2009	1765	2769	2522	2261	924	21

Number at age in the stock

Stock at age in numbers (x 1000)	0	1	2	3	4+
2005	46083	38483	31159	15854	9321
2006	41442	29837	29806	25669	13968
2007	39859	27970	24638	23869	10317
2008	43110	27124	22376	17895	8798
2009	46980	28932	21593	16354	6673
2010	43490	30668	23053	17510	5865
2011	44493*	29556	25226	19568	19746
* geometric mean (2008-2010)					

Maturity, weight-at-age in the stock and weight-at-age in the catch were estimated as the mean of the last 3 years. Different scenarios of constant harvest strategy with variation of the mean F (F_{bar} ages 0-3), calculated as the average of the last 3 years, were tested. Although during EWG 11-12, the target reference point (TRP) was set as the F_{MSY} = 0.31, calculated with the production model using 1970-2005 catch and effort data series, in the short and medium term forecasts the TRP used was the value of $F_{0.1}$ (0.25), calculated with Y/R analyses, in order to be consistent with the methodology applied for the calculation of the forecasts.

Stock recruitment

The recruitment used for the short term projection was estimated as the geometric mean from 2008-2010. The 2011 MEDITS data available for the GSA 25 were not used in order to rescale the recruitment of 2011 because the recruitment index showed by the survey is extremely variable each year.

7.28.1.3 Results

A short term projection (Table 7.28.1.3.1), assuming an F_{stq} of 0.11 in 2011 and a recruitment of 44,493 (thousand) individuals, shows that:

- Fishing at the F_{stq} (0.11) in the time frame from the year 2011 to 2012 generates an increase of the catch for 112% and an increase of the spawning stock biomass for 17% from the year 2012 to 2013.
- Fishing at $F_{0.1}$ (0.25) for the same time frame (2011-2012) generates an increase of the catch for 351% and a spawning stock biomass decrease of 7% from the year 2012 to 2013.
- A 90% increase of the F_{stq} (F = 0.20) generates an increase of catch for 279% and really low change (1%) of spawning stock biomass from the year 2012 to 2013.

Outlook until 2013

Table 7.28.1.3.1. Short term forecast in different F scenarios computed for piarel in GSA 25.

Basis: F_{stq} = mean (F_{bar}2008–2010); R(2011) = GM (2008–2010) = 41,195; F(2011) = 0.08; SSB(2011) = 2228 t; SSB(2012) = 2615 t; Catch (2011) = 281 t. Weights in tons.

Rationale	F scenario	F factor	Catch 2012	Catch 2013	SSB 2013	Change SSB 2012-2013 (%)	Change Catch 2010-2012 (%)
zero catch	0.00	0.0	0	0	3297	38	-100
High long-term yield ($F_{0.1}$)	0.25	2.3	707	671	2498	-7	351
Status quo	0.11	1.0	332	372	2922	17	112
Different scenarios	0.01	0.1	35	44	3257	36	-77
	0.02	0.2	70	87	3218	34	-55
	0.03	0.3	104	128	3179	32	-33
	0.04	0.4	138	167	3141	29	-12
	0.05	0.5	172	205	3103	27	10
	0.06	0.6	205	241	3066	25	31
	0.08	0.7	237	276	3030	23	51
	0.09	0.8	269	310	2993	21	72
	0.10	0.9	301	342	2958	19	92
	0.12	1.1	362	401	2888	15	131
	0.13	1.2	393	430	2853	13	151
	0.14	1.3	422	456	2820	11	170
	0.15	1.4	452	482	2786	10	189
	0.16	1.5	481	507	2754	8	207
	0.17	1.6	510	530	2721	6	225
	0.18	1.7	538	552	2689	4	244
	0.19	1.8	566	574	2658	2	261
	0.20	1.9	593	594	2627	1	279
	0.21	2.0	620	614	2596	-1	296

7.28.2 Medium term prediction

7.28.2.1 Method and justification

Medium term prediction from 2010 to 2020 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the Extended Survivor Analyses (XSA, Darby and Flatman, 1994) stock assessment that was applied for picarel stock in GSA 25 in the framework of the EWG-11-12 using the VPA Lowestoft software suite. The program used in the Medium term projections (10 years) were assuming an increasing trend of the F_{stq} toward the $F_{0.1}$ in 10 years, 5 years, in 1 year (2012) and a decrease of 10% each year as suggested by the recomendation of FAO-GFCM for the bottom trawling, that is the major fishery targeting this stock. The stock-recruitment relationship used geometric mean recruitment over the observed SSB range from 2008 to

2010. Runs were made with 500 simulations per run to try projecting with stochastic recruitment, multiplying the recruitment by log-normally distributed noise with a mean of 1 and a standard deviation of 0.3.

7.28.2.2 Input parameters

The maturity ogive, the natural mortality, the numbers of individuals and weight-at-age for the stock and for the catch were the same used in the short term forecast.

7.28.2.3 Results

In figure 7.28.2.3.1, the 5th, 25th, 50th, 75th and 95th percentile are showed for the SSB, recruitment and catches in t from 2005 to 2020, considering a constant increment of the F_{stq} toward $F_{0.1}$ (around 28% each year) from 2010 to 2015.

In figure 7.28.2.3.2, the 25th, 50th and 75th percentile are showed for the SSB, recruitment and catches in t from 2005 to 2020, considering a constant increment of the F_{stq} toward $F_{0.1}$ (around 14% each year) from 2010 to 2020.

It is interesting that the increasing fishing mortality determine in both cases a clear increase of the yeild not determing the decrease in the medium term of SSB under the levels oberved in the period 2005-2010.

In figure 7.28.2.3.3, the 25th, 50th, and 75th percentile are showed for the SSB, recruitment and catches in t from 2005 to 2020, considering a reduction of the F_{stq} toward $F_{0.1}$ in 2012.

In figure 7.28.2.3.4, the 25th, 50th, and 75th percentile are showed for the SSB, recruitment and catches in t from 2005 to 2020, considering a constant reduction of the F_{stq} of 10% each year.

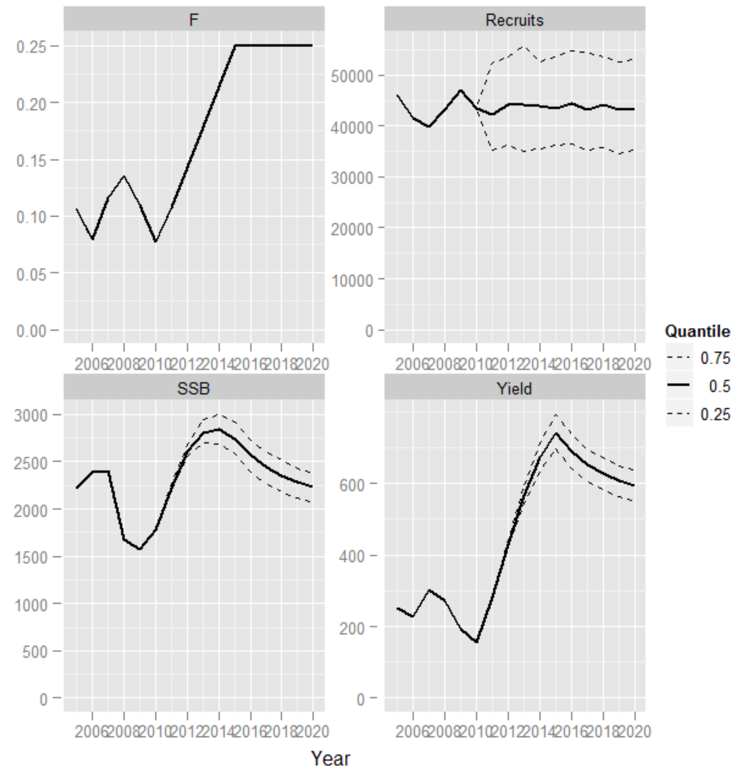


Fig. 7.28.2.3.1. Outputs of the medium term forecast computed for picarel in GSA 25 reaching the $F_{0.1}$ in 2015.

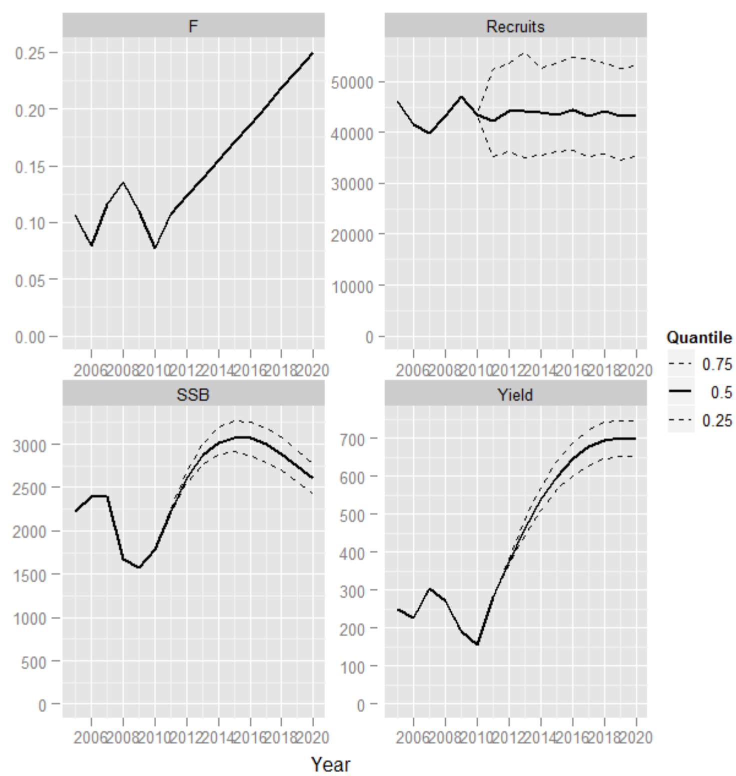


Fig. 7.28.2.3.2. Outputs of the medium term forecast computed for picarel in GSA 25 reaching the $F_{0.1}$ in 2020.

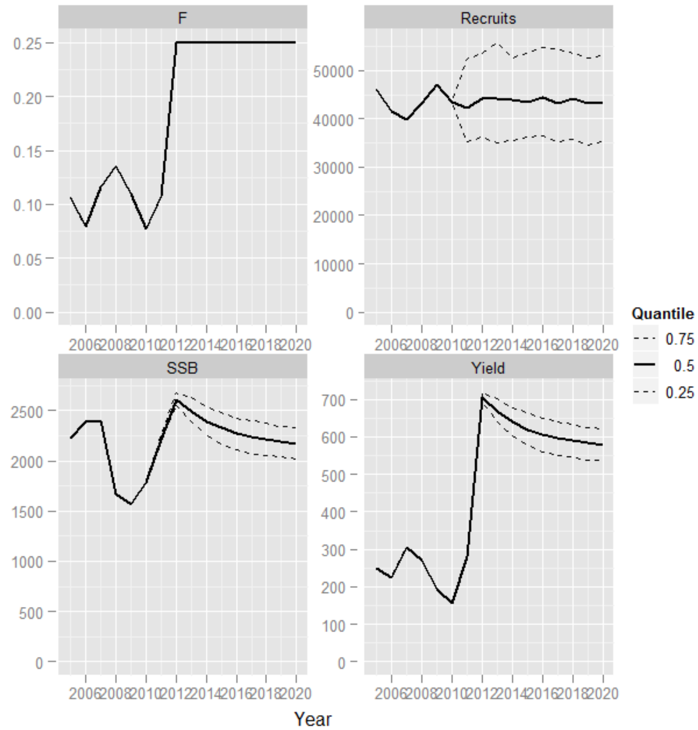


Fig. 7.28.2.3.3. Outputs of the medium term forecast computed for picarel in GSA 25 decreasing F_{stq} of 10% each year.

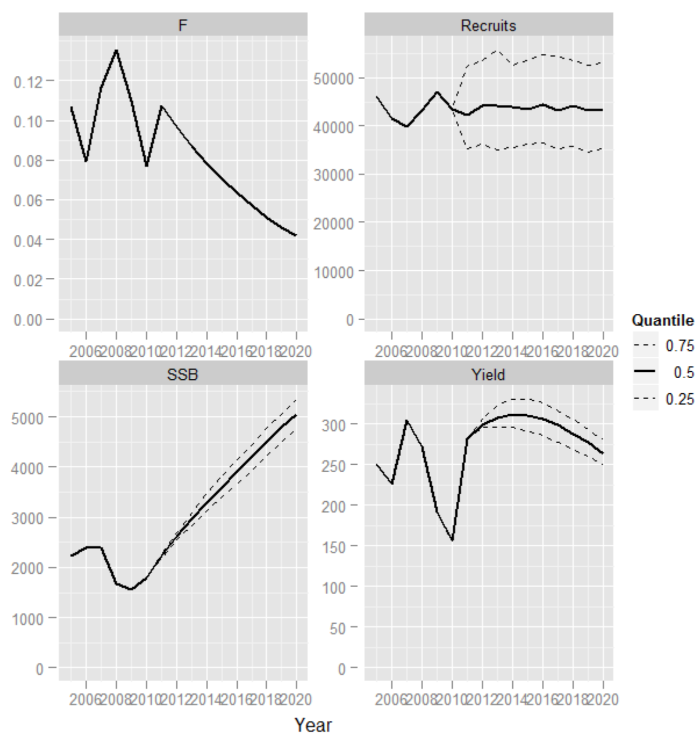


Fig. 7.28.2.3.4. Outputs of the medium term forecast computed for picarel in GSA 25 with F equal to $F_{0.1}$ since 2012.

7.28.3 Medium term prediction applying a surplus production model

Medium term projections were performed with ASPIC-P.

7.28.3.1 Method and justification

Considering the results of the analysis performed using the ASPIC.5.34 software (A Stock-Production model Incorporating Covariates) (Prager, 1994, 2005) assuming a Schaefer (1954) model, during EWG-11-12 an ASPIC-P was used for producing Biomass and Relative Yield forecasts for 10 years forward assuming two alternative scenarios, namely the status-quo current F (0.06) and an increment of F in order to drive mortality rate to the F_{msy} value (0.20) calculated with a bootstrapping approach. Also in this case the TRP utilized was different from the TRP set during the EWG 11-12, in order to be consistent with the mothodology used to run the projection. Data used as input are the results of the bootstrapped version of ASPIC non-equilibrium production model performed in EWG 11-12.

7.28.3.2 Input parameters

Data used as input are the results of the bootstrapped version of ASPIC non-equilibrium production model performed in EWG 11-12 (Table 17.28.3.2.1).

Table 17.28.3.2.1 – Input parameters and data.

MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	User/pgm guess	2nd guess	Estimated	User guess
B1/K	Starting relative biomass (in 1970)	9.079E-02	5.000E-01	3.284E-01	1	1
MSY	Maximum sustainable yield	9.682E+02	5.009E+02	4.258E+02	1	1
K	Maximum population size	9.483E+03	5.009E+03	2.555E+03	1	1
phi	Shape of production curve (Bmsy/K)	0.5	0.5	-	0	1
--------- Catchability Coefficients by Data Series ---------------						
q(1)	Weighted F (VPA 2+) and Landings	2.142E-04	1.552E-02	4.750E-01	1	1

MANAGEMENT and DERIVED PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Logistic formula	General formula
MSY	Maximum sustainable yield	9.682E+02	----	----
Bmsy	Stock biomass giving MSY	4.741E+03	K/2	K*n**(1/(1-n))
Fmsy	Fishing mortality rate at MSY	2.042E-01	MSY/Bmsy	MSY/Bmsy

n	Exponent in production function	2	----	----
g	Fletcher's gamma	4	----	[n**(n/(n-1))]/[n-1]
B./Bmsy	Ratio: B(2011)/Bmsy	5.869E-01	----	----
F./Fmsy	Ratio: F(2010)/Fmsy	2.560E-01	----	----
Fmsy/F.	Ratio: Fmsy/F(2010)	3.906E+00	----	----
Y.(Fmsy)	Approx. yield available at Fmsy in 2011	5.919E+02	MSY*B./Bmsy	MSY*B./Bmsy
	as proportion of MSY	6.113E-01	----	----
Ye.	Equilibrium yield available in 2011	8.030E+02		
	as proportion of MSY	8.293E-01	----	----

--------- Fishing effort rate at MSY in units of each CE or CC series ---------

fmsy(1)	Weighted F and Landings	9.534E+02	Fmsy/q(1)	Fmsy/q(1)

7.28.3.3 Results

In the first case, (status quo situation) a clear increase in B is observed, such increase will reach the value of B_{msy} in 2014 (Figure 7.28.3.3.1; Tables 7.28.3.3.1-5).

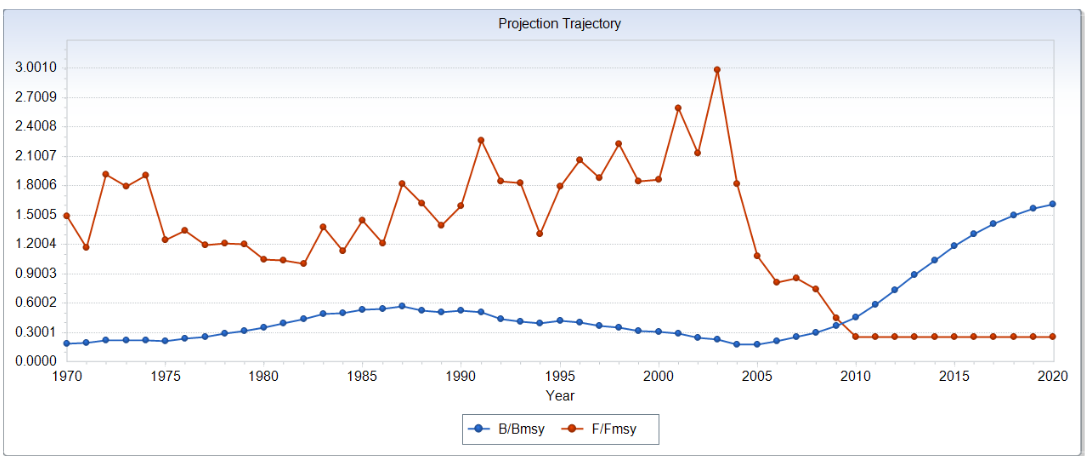


Fig. 7.28.3.3.1. Relative F and biomass projected with F_{stq}.

Table 7.28.3.3.1 – ASPIC projections with F_{stq}. Relative biomass B/B_{msy}

TRAJECTORY OF RELATIVE BIOMASS B/Bmsy (BOOTSTRAPPED)

Year	Point estimate	Estimated bias	Relative bias	App. 80% lower CL	App. 80% upper CL	App. 50% lower CL	App. 50% upper CL	Inter-quartile range	Relative IQ range
1970	0.1816	0.0001	0.03	0.1806	0.1827	0.1806	0.1827	0.0005	0.003
1971	0.1941	0.0001	0.04	0.1931	0.1953	0.1931	0.1953	0.0006	0.003
1972	0.2206	0.0001	0.04	0.2195	0.2219	0.2195	0.2219	0.0007	0.003
1973	0.2146	0.0001	0.04	0.2136	0.216	0.2136	0.216	0.0006	0.003
1974	0.2141	0.0001	0.04	0.2128	0.2155	0.2128	0.2155	0.0007	0.003

1975	0.2091	0.0001	0.04	0.2076	0.211	0.2076	0.211	0.0009	0.004
1976	0.2333	0.0001	0.03	0.2316	0.235	0.2316	0.235	0.001	0.004
1977	0.2538	0.0001	0.03	0.2519	0.2557	0.2519	0.2557	0.0012	0.005
1978	0.2835	0.0001	0.03	0.2814	0.2859	0.2814	0.2859	0.0012	0.004
1979	0.3136	0.0001	0.02	0.3113	0.316	0.3113	0.316	0.0012	0.004
1980	0.3451	0.0001	0.02	0.3428	0.3477	0.3428	0.3477	0.0014	0.004
1981	0.389	0.0001	0.02	0.3865	0.3919	0.3865	0.3919	0.0015	0.004
1982	0.4355	0.0001	0.03	0.4325	0.4385	0.4325	0.4385	0.0018	0.004
1983	0.4857	0.0002	0.03	0.4821	0.4894	0.4821	0.4894	0.0019	0.004
1984	0.4988	0.0002	0.03	0.4949	0.5024	0.4949	0.5024	0.002	0.004
1985	0.5353	0.0002	0.04	0.5306	0.5392	0.5306	0.5392	0.0022	0.004
1986	0.5374	0.0002	0.04	0.5327	0.5413	0.5327	0.5413	0.002	0.004
1987	0.5644	0.0002	0.04	0.5598	0.5684	0.5598	0.5684	0.0023	0.004
1988	0.5238	0.0002	0.04	0.5194	0.5273	0.5194	0.5273	0.002	0.004
1989	0.5092	0.0002	0.04	0.505	0.5126	0.505	0.5126	0.002	0.004
1990	0.5186	0.0003	0.05	0.5146	0.5221	0.5146	0.5221	0.0023	0.004
1991	0.507	0.0003	0.05	0.5027	0.5105	0.5027	0.5105	0.0024	0.005
1992	0.4366	0.0003	0.06	0.4329	0.4396	0.4329	0.4396	0.0019	0.004
1993	0.4129	0.0003	0.07	0.4091	0.4158	0.4091	0.4158	0.002	0.005
1994	0.3935	0.0003	0.08	0.3899	0.3967	0.3899	0.3967	0.0023	0.006
1995	0.4173	0.0004	0.09	0.4136	0.4209	0.4136	0.4209	0.0027	0.007
1996	0.4001	0.0005	0.12	0.3963	0.4042	0.3963	0.4042	0.0032	0.008
1997	0.3651	0.0006	0.15	0.3611	0.3699	0.3611	0.3699	0.0037	0.01
1998	0.3476	0.0007	0.2	0.3434	0.3534	0.3434	0.3534	0.0045	0.013
1999	0.3101	0.0009	0.28	0.3057	0.3171	0.3057	0.3171	0.0056	0.018
2000	0.3006	0.0011	0.37	0.2953	0.3099	0.2953	0.3099	0.0072	0.024
2001	0.2912	0.0015	0.51	0.2848	0.3035	0.2848	0.3035	0.0094	0.032
2002	0.244	0.0019	0.79	0.2356	0.2589	0.2356	0.2589	0.0112	0.046
2003	0.2261	0.0026	1.14	0.2152	0.2467	0.2152	0.2467	0.0155	0.068
2004	0.1775	0.0035	1.95	0.1625	0.207	0.1625	0.207	0.0194	0.109
2005	0.1776	0.0047	2.66	0.1565	0.2185	0.1565	0.2185	0.0271	0.153
2006	0.2061	0.0064	3.09	0.1767	0.2617	0.1767	0.2617	0.041	0.199
2007	0.2508	0.0084	3.35	0.2101	0.3247	0.2101	0.3247	0.0571	0.228
2008	0.2994	0.0107	3.57	0.2442	0.3957	0.2442	0.3957	0.078	0.26
2009	0.3619	0.0131	3.61	0.2882	0.4839	0.2882	0.4839	0.1024	0.283
2010	0.4571	0.015	3.29	0.3616	0.6085	0.3616	0.6085	0.1301	0.285
2011	0.5869	0.0159	2.71	0.4637	0.7649	0.4637	0.7649	0.1581	0.269
2012	0.7325	0.0152	2.08	0.586	0.9302	0.586	0.9302	0.1865	0.255
2013	0.8866	0.0129	1.45	0.7213	1.101	0.7213	1.101	0.2059	0.232
2014	1.04	0.0093	0.89	0.863	1.251	0.863	1.251	0.215	0.207
2015	1.183	0.0052	0.44	1.003	1.381	1.003	1.381	0.21	0.178
2016	1.309	0.0015	0.11	1.135	1.489	1.135	1.489	0.1968	0.15
2017	1.415	-0.0014	-0.1	1.251	1.574	1.251	1.574	0.1771	0.125
2018	1.5	-0.0034	-0.22	1.349	1.639	1.349	1.639	0.157	0.105
2019	1.565	-0.0044	-0.28	1.429	1.687	1.429	1.687	0.1396	0.089
2020	1.615	-0.0048	-0.3	1.493	1.722	1.493	1.722	0.1254	0.078
2021	1.652	-0.0049	-0.29	1.541	1.748	1.541	1.748	0.1133	0.069

Table 7.28.3.3.2 – ASPIC projections with F_{stq}. Relative F

TRAJECTORY OF RELATIVE FISHING MORTALITY RATE F/Fmsy (BOOTSTRAPPED)

Year	Point estimate	Estimated bias	Relative bias	App. 80% lower CL	App. 80% upper CL	App. 50% lower CL	App. 50% upper CL	Inter-quartile range	Relative IQ range
1970	1.485	-0.0002	-0.02	1.479	1.489	1.479	1.489	0.0019	0.001
1971	1.166	-0.0002	-0.02	1.163	1.169	1.163	1.169	0.0015	0.001
1972	1.918	-0.0005	-0.02	1.912	1.923	1.912	1.923	0.0024	0.001
1973	1.797	-0.0004	-0.02	1.791	1.804	1.791	1.804	0.0031	0.002
1974	1.904	-0.0003	-0.01	1.892	1.913	1.892	1.913	0.0039	0.002
1975	1.243	-0.0001	-0.01	1.234	1.25	1.234	1.25	0.003	0.002
1976	1.345	0	0	1.336	1.353	1.336	1.353	0.0037	0.003
1977	1.189	0	0	1.181	1.196	1.181	1.196	0.0034	0.003
1978	1.208	0	0	1.2	1.215	1.2	1.215	0.0033	0.003
1979	1.201	0	0	1.195	1.208	1.195	1.208	0.0032	0.003
1980	1.047	0	0	1.042	1.052	1.042	1.052	0.0023	0.002

1981	1.035	0	0	1.032	1.038	1.032	1.038	0.0019	0.002
1982	1.005	-0.0001	-0.01	1.002	1.007	1.002	1.007	0.0014	0.001
1983	1.378	-0.0001	-0.01	1.375	1.382	1.375	1.382	0.0019	0.001
1984	1.136	-0.0001	-0.01	1.134	1.139	1.134	1.139	0.0017	0.002
1985	1.444	-0.0002	-0.01	1.44	1.448	1.44	1.448	0.0023	0.002
1986	1.209	-0.0002	-0.01	1.204	1.212	1.204	1.212	0.0022	0.002
1987	1.822	-0.0002	-0.01	1.815	1.827	1.815	1.827	0.0033	0.002
1988	1.622	-0.0002	-0.01	1.617	1.626	1.617	1.626	0.0033	0.002
1989	1.397	-0.0003	-0.02	1.39	1.4	1.39	1.4	0.003	0.002
1990	1.598	-0.0003	-0.02	1.589	1.602	1.589	1.602	0.0037	0.002
1991	2.262	-0.0006	-0.03	2.251	2.267	2.251	2.267	0.0061	0.003
1992	1.849	-0.0006	-0.03	1.841	1.854	1.841	1.854	0.0057	0.003
1993	1.833	-0.0008	-0.05	1.823	1.839	1.823	1.839	0.0069	0.004
1994	1.307	-0.0008	-0.06	1.298	1.312	1.298	1.312	0.0063	0.005
1995	1.798	-0.0014	-0.08	1.783	1.806	1.783	1.806	0.0105	0.006
1996	2.065	-0.0021	-0.1	2.044	2.078	2.044	2.078	0.0165	0.008
1997	1.885	-0.0027	-0.14	1.86	1.899	1.86	1.899	0.0196	0.01
1998	2.23	-0.0045	-0.2	2.189	2.252	2.189	2.252	0.032	0.014
1999	1.847	-0.0051	-0.28	1.801	1.871	1.801	1.871	0.037	0.02
2000	1.861	-0.0069	-0.37	1.799	1.894	1.799	1.894	0.0495	0.027
2001	2.599	-0.0137	-0.53	2.472	2.669	2.472	2.669	0.099	0.038
2002	2.137	-0.0157	-0.73	1.98	2.224	1.98	2.224	0.1217	0.057
2003	2.985	-0.0292	-0.98	2.642	3.191	2.642	3.191	0.2704	0.091
2004	1.821	-0.0199	-1.09	1.516	2.024	1.516	2.024	0.2536	0.139
2005	1.078	-0.0105	-0.97	0.8581	1.239	0.8581	1.239	0.1933	0.179
2006	0.8112	-0.006	-0.74	0.6289	0.9563	0.6289	0.9563	0.1674	0.206
2007	0.8575	-0.0033	-0.38	0.6547	1.037	0.6547	1.037	0.1987	0.232
2008	0.7417	0.0009	0.12	0.5512	0.9196	0.5512	0.9196	0.1893	0.255
2009	0.4477	0.0026	0.59	0.3325	0.5636	0.3325	0.5636	0.1222	0.273
2010	0.256	0.0022	0.86	0.1937	0.322	0.1937	0.322	0.0691	0.27
2011	0.256	0.0022	0.86	0.1937	0.322	0.1937	0.322	0.0691	0.27
2012	0.256	0.0022	0.86	0.1937	0.322	0.1937	0.322	0.0691	0.27
2013	0.256	0.0022	0.86	0.1937	0.322	0.1937	0.322	0.0691	0.27
2014	0.256	0.0022	0.86	0.1937	0.322	0.1937	0.322	0.0691	0.27
2015	0.256	0.0022	0.86	0.1937	0.322	0.1937	0.322	0.0691	0.27
2016	0.256	0.0022	0.86	0.1937	0.322	0.1937	0.322	0.0691	0.27
2017	0.256	0.0022	0.86	0.1937	0.322	0.1937	0.322	0.0691	0.27
2018	0.256	0.0022	0.86	0.1937	0.322	0.1937	0.322	0.0691	0.27
2019	0.256	0.0022	0.86	0.1937	0.322	0.1937	0.322	0.0691	0.27
2020	0.256	0.0022	0.86	0.1937	0.322	0.1937	0.322	0.0691	0.27

Table 7.28.3.3.3 – ASPIC projections with F_{stq}. Projected yields.

TABLE OF PROJECTED YIELDS

2011	163.2	-0.5741	-0.0035	159.1	164.9	159.1	164.9	2.86	0.018
2012	200.6	-1.341	-0.0067	189.7	205.6	189.7	205.6	8.07	0.04
2013	238.8	-2.178	-0.0091	218.9	249.4	218.9	249.4	15.35	0.064
2014	275.7	-2.907	-0.0105	244.9	293.5	244.9	293.5	24.95	0.09
2015	309.2	-3.376	-0.0109	266.9	335.8	266.9	335.8	35.59	0.115
2016	338	-3.515	-0.0104	286.1	374.6	286.1	374.6	46.4	0.137
2017	361.6	-3.35	-0.0093	302	408.7	302	408.7	57.36	0.159
2018	380.2	-2.968	-0.0078	312.1	436.3	312.1	436.3	65.73	0.173
2019	394.4	-2.471	-0.0063	319.2	458.3	319.2	458.3	73.38	0.186
2020	405	-1.945	-0.0048	324.2	475.3	324.2	475.3	79.36	0.196

Table 7.28.3.3.4 – ASPIC projections with F_{stq}. Absolute biomass

TRAJECTORY OF ABSOLUTE BIOMASS (BOOTSTRAPPED)

Year	Point estimate	Estimated bias	Relative bias	App. 80% lower CL	App. 80% upper CL	App. 50% lower CL	App. 50% upper CL	Inter-quartile range	Relative IQ range
1970	860.9	0.7874	0.09	845.2	872	845.2	872	5.42	0.006

1971	920.5	0.8403	0.09	903.7	932.4	903.7	932.4	5.77	0.006
1972	1046	0.9039	0.09	1028	1059	1028	1059	6.06	0.006
1973	1018	0.9821	0.1	998.9	1031	998.9	1031	6.35	0.006
1974	1015	1.063	0.1	995.1	1029	995.1	1029	6.72	0.007
1975	991.5	1.138	0.11	969.4	1007	969.4	1007	7.45	0.008
1976	1106	1.192	0.11	1082	1123	1082	1123	8.26	0.007
1977	1203	1.237	0.1	1177	1222	1177	1222	9.21	0.008
1978	1344	1.264	0.09	1316	1365	1316	1365	10.03	0.007
1979	1487	1.278	0.09	1456	1510	1456	1510	11	0.007
1980	1636	1.277	0.08	1603	1661	1603	1661	11.96	0.007
1981	1844	1.264	0.07	1810	1871	1810	1871	12.44	0.007
1982	2065	1.248	0.06	2029	2093	2029	2093	12.94	0.006
1983	2303	1.234	0.05	2267	2332	2267	2332	13.06	0.006
1984	2365	1.218	0.05	2329	2394	2329	2394	12.92	0.005
1985	2538	1.204	0.05	2502	2567	2502	2567	12.47	0.005
1986	2548	1.202	0.05	2513	2577	2513	2577	11.77	0.005
1987	2676	1.195	0.04	2643	2704	2643	2704	11.98	0.004
1988	2484	1.19	0.05	2451	2511	2451	2511	12.31	0.005
1989	2414	1.196	0.05	2383	2441	2383	2441	11.64	0.005
1990	2459	1.228	0.05	2429	2484	2429	2484	11.12	0.005
1991	2404	1.273	0.05	2377	2428	2377	2428	11.35	0.005
1992	2070	1.356	0.07	2045	2095	2045	2095	11.9	0.006
1993	1958	1.486	0.08	1934	1984	1934	1984	12.56	0.006
1994	1866	1.667	0.09	1843	1891	1843	1891	13.87	0.007
1995	1978	1.919	0.1	1959	2003	1959	2003	13.69	0.007
1996	1897	2.252	0.12	1879	1924	1879	1924	15.89	0.008
1997	1731	2.705	0.16	1712	1757	1712	1757	18.37	0.011
1998	1648	3.338	0.2	1625	1678	1625	1678	22.64	0.014
1999	1470	4.214	0.29	1446	1508	1446	1508	28.12	0.019
2000	1425	5.41	0.38	1400	1472	1400	1472	34.31	0.024
2001	1380	7.03	0.51	1346	1440	1346	1440	42.97	0.031
2002	1157	9.28	0.8	1118	1234	1118	1234	57.16	0.049
2003	1072	12.42	1.16	1021	1178	1021	1178	78.44	0.073
2004	841.6	16.82	2	771.2	983	771.2	983	106.7	0.127
2005	841.9	22.82	2.71	742.4	1039	742.4	1039	143.4	0.17
2006	977.3	30.56	3.13	837.9	1246	837.9	1246	202.1	0.207
2007	1189	39.94	3.36	1000	1542	1000	1542	276.7	0.233
2008	1420	50.49	3.56	1162	1896	1162	1896	363.6	0.256
2009	1716	61.13	3.56	1372	2333	1372	2333	477.8	0.278
2010	2168	69.66	3.21	1721	2919	1721	2919	600.3	0.277
2011	2783	72.85	2.62	2220	3648	2220	3648	720.4	0.259
2012	3473	68.58	1.97	2807	4413	2807	4413	827.8	0.238
2013	4204	56.56	1.35	3455	5188	3455	5188	897.9	0.214
2014	4930	38.97	0.79	4134	5906	4134	5906	922	0.187
2015	5608	19.63	0.35	4803	6531	4803	6531	904.4	0.161
2016	6207	2.251	0.04	5426	7060	5426	7060	840	0.135
2017	6708	-10.86	-0.16	5978	7454	5978	7454	789.8	0.118
2018	7110	-19.15	-0.27	6442	7764	6442	7764	721.1	0.101
2019	7422	-23.27	-0.31	6818	8005	6818	8005	638	0.086
2020	7657	-24.38	-0.32	7104	8162	7104	8162	586.4	0.077
2021	7831	-23.63	-0.3	7328	8305	7328	8305	545.4	0.07

Table 7.28.3.3.5 – ASPIC projections with F_{stq}. Absolute F

TRAJECTORY OF ABSOLUTE FISHING MORTALITY RATE (BOOTSTRAPPED)

Year	Point estimate	Estimated bias	Relative bias	App. 80% lower CL	App. 80% upper CL	App. 50% lower CL	App. 50% upper CL	Inter-quartile range	Relative IQ range
1970	0.3032	0.0002	0.07	0.2993	0.3085	0.2993	0.3085	0.0018	0.006
1971	0.2382	0.0001	0.06	0.2352	0.2422	0.2352	0.2422	0.0013	0.006
1972	0.3916	0.0002	0.05	0.3867	0.3981	0.3867	0.3981	0.0022	0.006
1973	0.367	0.0002	0.06	0.3621	0.3735	0.3621	0.3735	0.0022	0.006
1974	0.3888	0.0003	0.08	0.383	0.3962	0.383	0.3962	0.0027	0.007

1975	0.2538	0.0002	0.09	0.2498	0.2588	0.2498	0.2588	0.0019	0.007
1976	0.2746	0.0003	0.09	0.2703	0.28	0.2703	0.28	0.0021	0.008
1977	0.2427	0.0002	0.1	0.2389	0.2474	0.2389	0.2474	0.0018	0.008
1978	0.2466	0.0002	0.09	0.2428	0.2513	0.2428	0.2513	0.0018	0.007
1979	0.2453	0.0002	0.09	0.2416	0.2497	0.2416	0.2497	0.0018	0.007
1980	0.2138	0.0002	0.08	0.2107	0.2175	0.2107	0.2175	0.0015	0.007
1981	0.2113	0.0001	0.07	0.2084	0.2147	0.2084	0.2147	0.0014	0.006
1982	0.2052	0.0001	0.05	0.2024	0.2081	0.2024	0.2081	0.0012	0.006
1983	0.2814	0.0001	0.05	0.2779	0.2852	0.2779	0.2852	0.0016	0.006
1984	0.2321	0.0001	0.04	0.2292	0.235	0.2292	0.235	0.0012	0.005
1985	0.2949	0.0001	0.03	0.2915	0.2985	0.2915	0.2985	0.0014	0.005
1986	0.2469	0.0001	0.03	0.2441	0.2497	0.2441	0.2497	0.0011	0.005
1987	0.3722	0.0001	0.02	0.3682	0.3763	0.3682	0.3763	0.0016	0.004
1988	0.3313	0.0001	0.02	0.3277	0.3351	0.3277	0.3351	0.0014	0.004
1989	0.2852	0.0001	0.02	0.2821	0.2884	0.2821	0.2884	0.0013	0.004
1990	0.3262	0	0.01	0.3228	0.3297	0.3228	0.3297	0.0015	0.004
1991	0.4618	0	0.01	0.4566	0.4669	0.4566	0.4669	0.0024	0.005
1992	0.3776	0	0.01	0.3728	0.382	0.3728	0.382	0.0023	0.006
1993	0.3742	0	0	0.3691	0.3785	0.3691	0.3785	0.0026	0.007
1994	0.2669	-0.0001	-0.02	0.263	0.2697	0.263	0.2697	0.0019	0.007
1995	0.3671	-0.0001	-0.04	0.3615	0.3706	0.3615	0.3706	0.003	0.008
1996	0.4217	-0.0003	-0.07	0.4149	0.426	0.4149	0.426	0.0039	0.009
1997	0.3849	-0.0004	-0.11	0.3782	0.3896	0.3782	0.3896	0.0047	0.012
1998	0.4555	-0.0007	-0.16	0.4456	0.462	0.4456	0.462	0.0077	0.017
1999	0.3772	-0.0009	-0.24	0.3661	0.3837	0.3661	0.3837	0.0083	0.022
2000	0.38	-0.0013	-0.33	0.3656	0.3875	0.3656	0.3875	0.0108	0.028
2001	0.5307	-0.0026	-0.49	0.5028	0.5458	0.5028	0.5458	0.0222	0.042
2002	0.4364	-0.003	-0.69	0.4032	0.4546	0.4032	0.4546	0.0264	0.061
2003	0.6096	-0.0056	-0.92	0.5374	0.6516	0.5374	0.6516	0.0611	0.1
2004	0.3718	-0.0038	-1.02	0.3082	0.4127	0.3082	0.4127	0.0536	0.144
2005	0.2202	-0.002	-0.91	0.1742	0.2529	0.1742	0.2529	0.0407	0.185
2006	0.1657	-0.0011	-0.69	0.1294	0.1943	0.1294	0.1943	0.0354	0.214
2007	0.1751	-0.0006	-0.35	0.1323	0.2093	0.1323	0.2093	0.0411	0.235
2008	0.1515	0.0002	0.12	0.112	0.1858	0.112	0.1858	0.039	0.257
2009	0.0914	0.0005	0.57	0.0674	0.1145	0.0674	0.1145	0.0242	0.265
2010	0.0523	0.0004	0.82	0.0392	0.0656	0.0392	0.0656	0.0136	0.26
2011	0.0523	0.0004	0.82	0.0392	0.0656	0.0392	0.0656	0.0136	0.26
2012	0.0523	0.0004	0.82	0.0392	0.0656	0.0392	0.0656	0.0136	0.26
2013	0.0523	0.0004	0.82	0.0392	0.0656	0.0392	0.0656	0.0136	0.26
2014	0.0523	0.0004	0.82	0.0392	0.0656	0.0392	0.0656	0.0136	0.26
2015	0.0523	0.0004	0.82	0.0392	0.0656	0.0392	0.0656	0.0136	0.26
2016	0.0523	0.0004	0.82	0.0392	0.0656	0.0392	0.0656	0.0136	0.26
2017	0.0523	0.0004	0.82	0.0392	0.0656	0.0392	0.0656	0.0136	0.26
2018	0.0523	0.0004	0.82	0.0392	0.0656	0.0392	0.0656	0.0136	0.26
2019	0.0523	0.0004	0.82	0.0392	0.0656	0.0392	0.0656	0.0136	0.26
2020	0.0523	0.0004	0.82	0.0392	0.0656	0.0392	0.0656	0.0136	0.26

With the increase of F toward the F_{msy} (0.20), calculated with the bootstrapped method, the level of B will constantly increase toward B_{msy}, reaching the 90% of it in 2020 (Fig. 7.28.3.3.2; Tables 7.28.3.3.5-10).

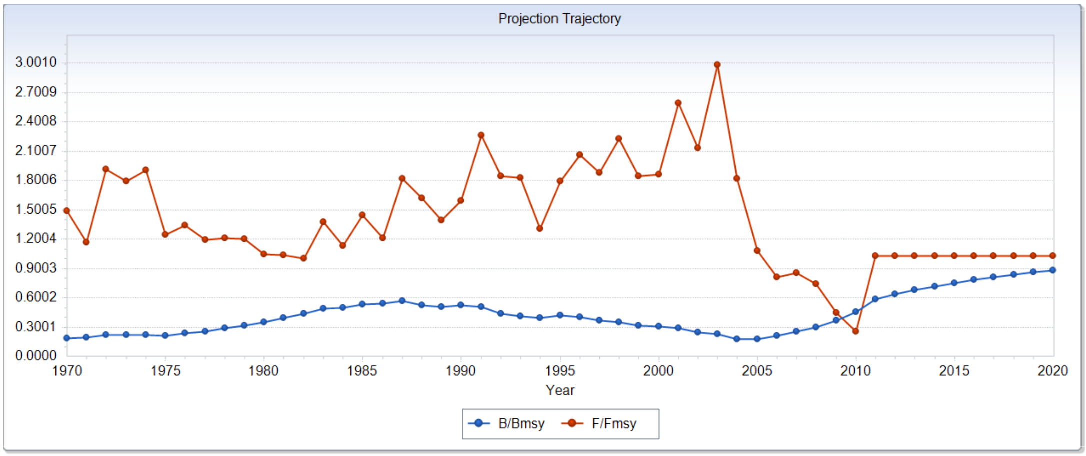


Fig. 7.28.3.3.2. Relative F and biomass projected with F_{MSY}.

Table 7.28.3.3.6. ASPIC projections with F_{MSY}. Relative biomass B/B_{msy}

TRAJECTORY OF RELATIVE BIOMASS B/Bmsy (BOOTSTRAPPED)

Year	Point estimate	Estimated bias	Relative bias	App. 80% lower CL	App. 80% upper CL	App. 50% lower CL	App. 50% upper CL	Inter-quartile range	Relative IQ range
1970	1.816E-01	6.311E-05	0.03%	1.806E-01	1.827E-01	1.806E-01	1.827E-01	5.409E-04	0.003
1971	1.941E-01	7.011E-05	0.04%	1.931E-01	1.953E-01	1.931E-01	1.953E-01	5.597E-04	0.003
1972	2.206E-01	9.501E-05	0.04%	2.195E-01	2.219E-01	2.195E-01	2.219E-01	6.945E-04	0.003
1973	2.146E-01	9.362E-05	0.04%	2.136E-01	2.160E-01	2.136E-01	2.160E-01	5.690E-04	0.003
1974	2.141E-01	9.199E-05	0.04%	2.128E-01	2.155E-01	2.128E-01	2.155E-01	7.125E-04	0.003
1975	2.091E-01	7.694E-05	0.04%	2.076E-01	2.110E-01	2.076E-01	2.110E-01	9.241E-04	0.004
1976	2.333E-01	7.916E-05	0.03%	2.316E-01	2.350E-01	2.316E-01	2.350E-01	1.028E-03	0.004
1977	2.538E-01	7.489E-05	0.03%	2.519E-01	2.557E-01	2.519E-01	2.557E-01	1.152E-03	0.005
1978	2.835E-01	7.533E-05	0.03%	2.814E-01	2.859E-01	2.814E-01	2.859E-01	1.184E-03	0.004
1979	3.136E-01	7.523E-05	0.02%	3.113E-01	3.160E-01	3.113E-01	3.160E-01	1.225E-03	0.004
1980	3.451E-01	7.579E-05	0.02%	3.428E-01	3.477E-01	3.428E-01	3.477E-01	1.363E-03	0.004
1981	3.890E-01	9.018E-05	0.02%	3.865E-01	3.919E-01	3.865E-01	3.919E-01	1.533E-03	0.004
1982	4.355E-01	1.144E-04	0.03%	4.325E-01	4.385E-01	4.325E-01	4.385E-01	1.758E-03	0.004
1983	4.857E-01	1.519E-04	0.03%	4.821E-01	4.894E-01	4.821E-01	4.894E-01	1.915E-03	0.004
1984	4.988E-01	1.609E-04	0.03%	4.949E-01	5.024E-01	4.949E-01	5.024E-01	2.002E-03	0.004
1985	5.353E-01	1.968E-04	0.04%	5.306E-01	5.392E-01	5.306E-01	5.392E-01	2.156E-03	0.004
1986	5.374E-01	2.080E-04	0.04%	5.327E-01	5.413E-01	5.327E-01	5.413E-01	1.988E-03	0.004
1987	5.644E-01	2.449E-04	0.04%	5.598E-01	5.684E-01	5.598E-01	5.684E-01	2.307E-03	0.004
1988	5.238E-01	2.224E-04	0.04%	5.194E-01	5.273E-01	5.194E-01	5.273E-01	1.967E-03	0.004
1989	5.092E-01	2.253E-04	0.04%	5.050E-01	5.126E-01	5.050E-01	5.126E-01	1.980E-03	0.004
1990	5.186E-01	2.582E-04	0.05%	5.146E-01	5.221E-01	5.146E-01	5.221E-01	2.322E-03	0.004
1991	5.070E-01	2.786E-04	0.05%	5.027E-01	5.105E-01	5.027E-01	5.105E-01	2.358E-03	0.005
1992	4.366E-01	2.509E-04	0.06%	4.329E-01	4.396E-01	4.329E-01	4.396E-01	1.930E-03	0.004
1993	4.129E-01	2.708E-04	0.07%	4.091E-01	4.158E-01	4.091E-01	4.158E-01	2.020E-03	0.005
1994	3.935E-01	3.039E-04	0.08%	3.899E-01	3.967E-01	3.899E-01	3.967E-01	2.289E-03	0.006
1995	4.173E-01	3.951E-04	0.09%	4.136E-01	4.209E-01	4.136E-01	4.209E-01	2.733E-03	0.007
1996	4.001E-01	4.714E-04	0.12%	3.963E-01	4.042E-01	3.963E-01	4.042E-01	3.186E-03	0.008
1997	3.651E-01	5.562E-04	0.15%	3.611E-01	3.699E-01	3.611E-01	3.699E-01	3.691E-03	0.010
1998	3.476E-01	6.939E-04	0.20%	3.434E-01	3.534E-01	3.434E-01	3.534E-01	4.514E-03	0.013
1999	3.101E-01	8.627E-04	0.28%	3.057E-01	3.171E-01	3.057E-01	3.171E-01	5.597E-03	0.018
2000	3.006E-01	1.124E-03	0.37%	2.953E-01	3.099E-01	2.953E-01	3.099E-01	7.192E-03	0.024
2001	2.912E-01	1.475E-03	0.51%	2.848E-01	3.035E-01	2.848E-01	3.035E-01	9.365E-03	0.032
2002	2.440E-01	1.923E-03	0.79%	2.356E-01	2.589E-01	2.356E-01	2.589E-01	1.121E-02	0.046
2003	2.261E-01	2.578E-03	1.14%	2.152E-01	2.467E-01	2.152E-01	2.467E-01	1.549E-02	0.068
2004	1.775E-01	3.462E-03	1.95%	1.625E-01	2.070E-01	1.625E-01	2.070E-01	1.935E-02	0.109
2005	1.776E-01	4.717E-03	2.66%	1.565E-01	2.185E-01	1.565E-01	2.185E-01	2.713E-02	0.153
2006	2.061E-01	6.370E-03	3.09%	1.767E-01	2.617E-01	1.767E-01	2.617E-01	4.104E-02	0.199
2007	2.508E-01	8.398E-03	3.35%	2.101E-01	3.247E-01	2.101E-01	3.247E-01	5.713E-02	0.228
2008	2.994E-01	1.070E-02	3.57%	2.442E-01	3.957E-01	2.442E-01	3.957E-01	7.799E-02	0.260

2009	3.619E-01	1.305E-02	3.61%	2.882E-01	4.839E-01	2.882E-01	4.839E-01	1.024E-01	0.283
2010	4.571E-01	1.502E-02	3.29%	3.616E-01	6.085E-01	3.616E-01	6.085E-01	1.301E-01	0.285
2011	5.869E-01	1.592E-02	2.71%	4.637E-01	7.649E-01	4.637E-01	7.649E-01	1.581E-01	0.269
2012	6.325E-01	1.589E-02	2.51%	4.853E-01	8.339E-01	4.853E-01	8.339E-01	1.837E-01	0.290
2013	6.754E-01	1.532E-02	2.27%	5.057E-01	8.969E-01	5.057E-01	8.969E-01	2.069E-01	0.306
2014	7.152E-01	1.421E-02	1.99%	5.249E-01	9.530E-01	5.249E-01	9.530E-01	2.271E-01	0.318
2015	7.515E-01	1.266E-02	1.68%	5.427E-01	1.002E+00	5.427E-01	1.002E+00	2.442E-01	0.325
2016	7.841E-01	1.078E-02	1.37%	5.592E-01	1.044E+00	5.592E-01	1.044E+00	2.580E-01	0.329
2017	8.130E-01	8.691E-03	1.07%	5.761E-01	1.078E+00	5.761E-01	1.078E+00	2.687E-01	0.331
2018	8.383E-01	6.531E-03	0.78%	5.926E-01	1.107E+00	5.926E-01	1.107E+00	2.768E-01	0.330
2019	8.602E-01	4.401E-03	0.51%	6.081E-01	1.131E+00	6.081E-01	1.131E+00	2.825E-01	0.328
2020	8.791E-01	2.381E-03	0.27%	6.224E-01	1.150E+00	6.224E-01	1.150E+00	2.865E-01	0.326
2021	8.951E-01	5.236E-04	0.06%	6.338E-01	1.165E+00	6.338E-01	1.165E+00	2.891E-01	0.323

Table 7.28.3.3.7. ASPIC projections with F_{MSY}. Relative F.

TRAJECTORY OF RELATIVE FISHING MORTALITY RATE F/Fmsy (BOOTSTRAPPED)

Year	Point estimate	Estimated bias	Relative bias	App. 80% lower CL	App. 80% upper CL	App. 50% lower CL	App. 50% upper CL	Inter-quartile range	Relative IQ range
1970	1.485E+00	-2.334E-04	-0.02%	1.479E+00	1.489E+00	1.479E+00	1.489E+00	1.893E-03	0.001
1971	1.166E+00	-2.332E-04	-0.02%	1.163E+00	1.169E+00	1.163E+00	1.169E+00	1.477E-03	0.001
1972	1.918E+00	-4.580E-04	-0.02%	1.912E+00	1.923E+00	1.912E+00	1.923E+00	2.370E-03	0.001
1973	1.797E+00	-3.994E-04	-0.02%	1.791E+00	1.804E+00	1.791E+00	1.804E+00	3.074E-03	0.002
1974	1.904E+00	-2.799E-04	-0.01%	1.892E+00	1.913E+00	1.892E+00	1.913E+00	3.949E-03	0.002
1975	1.243E+00	-6.470E-05	-0.01%	1.234E+00	1.250E+00	1.234E+00	1.250E+00	3.009E-03	0.002
1976	1.345E+00	-3.729E-05	0.00%	1.336E+00	1.353E+00	1.336E+00	1.353E+00	3.728E-03	0.003
1977	1.189E+00	6.310E-06	0.00%	1.181E+00	1.196E+00	1.181E+00	1.196E+00	3.364E-03	0.003
1978	1.208E+00	1.141E-05	0.00%	1.200E+00	1.215E+00	1.200E+00	1.215E+00	3.257E-03	0.003
1979	1.201E+00	2.146E-05	0.00%	1.195E+00	1.208E+00	1.195E+00	1.208E+00	3.162E-03	0.003
1980	1.047E+00	8.354E-06	0.00%	1.042E+00	1.052E+00	1.042E+00	1.052E+00	2.336E-03	0.002
1981	1.035E+00	-2.635E-05	0.00%	1.032E+00	1.038E+00	1.032E+00	1.038E+00	1.894E-03	0.002
1982	1.005E+00	-6.520E-05	-0.01%	1.002E+00	1.007E+00	1.002E+00	1.007E+00	1.361E-03	0.001
1983	1.378E+00	-1.090E-04	-0.01%	1.375E+00	1.382E+00	1.375E+00	1.382E+00	1.931E-03	0.001
1984	1.136E+00	-1.142E-04	-0.01%	1.134E+00	1.139E+00	1.134E+00	1.139E+00	1.716E-03	0.002
1985	1.444E+00	-1.837E-04	-0.01%	1.440E+00	1.448E+00	1.440E+00	1.448E+00	2.309E-03	0.002
1986	1.209E+00	-1.632E-04	-0.01%	1.204E+00	1.212E+00	1.204E+00	1.212E+00	2.208E-03	0.002
1987	1.822E+00	-2.494E-04	-0.01%	1.815E+00	1.827E+00	1.815E+00	1.827E+00	3.288E-03	0.002
1988	1.622E+00	-2.338E-04	-0.01%	1.617E+00	1.626E+00	1.617E+00	1.626E+00	3.333E-03	0.002
1989	1.397E+00	-2.565E-04	-0.02%	1.390E+00	1.400E+00	1.390E+00	1.400E+00	3.010E-03	0.002
1990	1.598E+00	-3.374E-04	-0.02%	1.589E+00	1.602E+00	1.589E+00	1.602E+00	3.748E-03	0.002
1991	2.262E+00	-6.076E-04	-0.03%	2.251E+00	2.267E+00	2.251E+00	2.267E+00	6.076E-03	0.003
1992	1.849E+00	-6.473E-04	-0.03%	1.841E+00	1.854E+00	1.841E+00	1.854E+00	5.692E-03	0.003
1993	1.833E+00	-8.339E-04	-0.05%	1.823E+00	1.839E+00	1.823E+00	1.839E+00	6.946E-03	0.004
1994	1.307E+00	-7.781E-04	-0.06%	1.298E+00	1.312E+00	1.298E+00	1.312E+00	6.303E-03	0.005
1995	1.798E+00	-1.361E-03	-0.08%	1.783E+00	1.806E+00	1.783E+00	1.806E+00	1.054E-02	0.006
1996	2.065E+00	-2.114E-03	-0.10%	2.044E+00	2.078E+00	2.044E+00	2.078E+00	1.649E-02	0.008
1997	1.885E+00	-2.682E-03	-0.14%	1.860E+00	1.899E+00	1.860E+00	1.899E+00	1.962E-02	0.010
1998	2.230E+00	-4.465E-03	-0.20%	2.189E+00	2.252E+00	2.189E+00	2.252E+00	3.204E-02	0.014
1999	1.847E+00	-5.133E-03	-0.28%	1.801E+00	1.871E+00	1.801E+00	1.871E+00	3.704E-02	0.020
2000	1.861E+00	-6.916E-03	-0.37%	1.799E+00	1.894E+00	1.799E+00	1.894E+00	4.954E-02	0.027
2001	2.599E+00	-1.367E-02	-0.53%	2.472E+00	2.669E+00	2.472E+00	2.669E+00	9.904E-02	0.038
2002	2.137E+00	-1.571E-02	-0.73%	1.980E+00	2.224E+00	1.980E+00	2.224E+00	1.217E-01	0.057
2003	2.985E+00	-2.919E-02	-0.98%	2.642E+00	3.191E+00	2.642E+00	3.191E+00	2.704E-01	0.091
2004	1.821E+00	-1.988E-02	-1.09%	1.516E+00	2.024E+00	1.516E+00	2.024E+00	2.536E-01	0.139
2005	1.078E+00	-1.050E-02	-0.97%	8.581E-01	1.239E+00	8.581E-01	1.239E+00	1.933E-01	0.179
2006	8.112E-01	-6.010E-03	-0.74%	6.289E-01	9.563E-01	6.289E-01	9.563E-01	1.674E-01	0.206
2007	8.575E-01	-3.271E-03	-0.38%	6.547E-01	1.037E+00	6.547E-01	1.037E+00	1.987E-01	0.232
2008	7.417E-01	8.781E-04	0.12%	5.512E-01	9.196E-01	5.512E-01	9.196E-01	1.893E-01	0.255
2009	4.477E-01	2.621E-03	0.59%	3.325E-01	5.636E-01	3.325E-01	5.636E-01	1.222E-01	0.273
2010	2.560E-01	2.205E-03	0.86%	1.937E-01	3.220E-01	1.937E-01	3.220E-01	6.911E-02	0.270
2011	1.024E+00	8.820E-03	0.86%	7.748E-01	1.288E+00	7.748E-01	1.288E+00	2.764E-01	0.270
2012	1.024E+00	8.820E-03	0.86%	7.748E-01	1.288E+00	7.748E-01	1.288E+00	2.764E-01	0.270
2013	1.024E+00	8.820E-03	0.86%	7.748E-01	1.288E+00	7.748E-01	1.288E+00	2.764E-01	0.270
2014	1.024E+00	8.820E-03	0.86%	7.748E-01	1.288E+00	7.748E-01	1.288E+00	2.764E-01	0.270

2015	1.024E+00	8.820E-03	0.86%	7.748E-01	1.288E+00	7.748E-01	1.288E+00	2.764E-01	0.270
2016	1.024E+00	8.820E-03	0.86%	7.748E-01	1.288E+00	7.748E-01	1.288E+00	2.764E-01	0.270
2017	1.024E+00	8.820E-03	0.86%	7.748E-01	1.288E+00	7.748E-01	1.288E+00	2.764E-01	0.270
2018	1.024E+00	8.820E-03	0.86%	7.748E-01	1.288E+00	7.748E-01	1.288E+00	2.764E-01	0.270
2019	1.024E+00	8.820E-03	0.86%	7.748E-01	1.288E+00	7.748E-01	1.288E+00	2.764E-01	0.270
2020	1.024E+00	8.820E-03	0.86%	7.748E-01	1.288E+00	7.748E-01	1.288E+00	2.764E-01	0.270

Table 7.28.3.3.8. ASPIC projections with F_{MSY}. Projected yields.

TABLE OF PROJECTED YIELDS

2011	6.046E+02	-2.532E+00	-0.42%	5.974E+02	6.053E+02	5.974E+02	6.053E+02	3.896E+00	0.006
2012	6.486E+02	-5.756E+00	-0.89%	6.243E+02	6.536E+02	6.243E+02	6.536E+02	1.323E+01	0.020
2013	6.896E+02	-9.165E+00	-1.33%	6.487E+02	6.989E+02	6.487E+02	6.989E+02	2.266E+01	0.033
2014	7.274E+02	-1.268E+01	-1.74%	6.713E+02	7.392E+02	6.713E+02	7.392E+02	3.043E+01	0.042
2015	7.615E+02	-1.620E+01	-2.13%	6.922E+02	7.748E+02	6.922E+02	7.748E+02	3.645E+01	0.048
2016	7.920E+02	-1.963E+01	-2.48%	7.114E+02	8.056E+02	7.114E+02	8.056E+02	4.096E+01	0.052
2017	8.188E+02	-2.288E+01	-2.79%	7.290E+02	8.315E+02	7.290E+02	8.315E+02	4.414E+01	0.054
2018	8.422E+02	-2.586E+01	-3.07%	7.483E+02	8.539E+02	7.483E+02	8.539E+02	4.453E+01	0.053
2019	8.624E+02	-2.855E+01	-3.31%	7.639E+02	8.725E+02	7.639E+02	8.725E+02	4.442E+01	0.052
2020	8.797E+02	-3.092E+01	-3.51%	7.774E+02	8.883E+02	7.774E+02	8.883E+02	4.706E+01	0.053

Table 7.28.3.3.9. ASPIC projections with F_{MSY}. Absolute biomass.

TRAJECTORY OF ABSOLUTE BIOMASS (BOOTSTRAPPED)

Year	Point estimate	Estimated bias	Relative bias	App. 80% lower CL	App. 80% upper CL	App. 50% lower CL	App. 50% upper CL	Inter-quartile range	Relative IQ range
1970	8.609E+02	7.874E-01	0.09%	8.452E+02	8.720E+02	8.452E+02	8.720E+02	5.416E+00	0.006
1971	9.205E+02	8.403E-01	0.09%	9.037E+02	9.324E+02	9.037E+02	9.324E+02	5.774E+00	0.006
1972	1.046E+03	9.039E-01	0.09%	1.028E+03	1.059E+03	1.028E+03	1.059E+03	6.062E+00	0.006
1973	1.018E+03	9.821E-01	0.10%	9.989E+02	1.031E+03	9.989E+02	1.031E+03	6.354E+00	0.006
1974	1.015E+03	1.063E+00	0.10%	9.951E+02	1.029E+03	9.951E+02	1.029E+03	6.719E+00	0.007
1975	9.915E+02	1.138E+00	0.11%	9.694E+02	1.007E+03	9.694E+02	1.007E+03	7.446E+00	0.008
1976	1.106E+03	1.192E+00	0.11%	1.082E+03	1.123E+03	1.082E+03	1.123E+03	8.261E+00	0.007
1977	1.203E+03	1.237E+00	0.10%	1.177E+03	1.222E+03	1.177E+03	1.222E+03	9.205E+00	0.008
1978	1.344E+03	1.264E+00	0.09%	1.316E+03	1.365E+03	1.316E+03	1.365E+03	1.003E+01	0.007
1979	1.487E+03	1.278E+00	0.09%	1.456E+03	1.510E+03	1.456E+03	1.510E+03	1.100E+01	0.007
1980	1.636E+03	1.277E+00	0.08%	1.603E+03	1.661E+03	1.603E+03	1.661E+03	1.196E+01	0.007
1981	1.844E+03	1.264E+00	0.07%	1.810E+03	1.871E+03	1.810E+03	1.871E+03	1.244E+01	0.007
1982	2.065E+03	1.248E+00	0.06%	2.029E+03	2.093E+03	2.029E+03	2.093E+03	1.294E+01	0.006
1983	2.303E+03	1.234E+00	0.05%	2.267E+03	2.332E+03	2.267E+03	2.332E+03	1.306E+01	0.006
1984	2.365E+03	1.218E+00	0.05%	2.329E+03	2.394E+03	2.329E+03	2.394E+03	1.292E+01	0.005
1985	2.538E+03	1.204E+00	0.05%	2.502E+03	2.567E+03	2.502E+03	2.567E+03	1.247E+01	0.005
1986	2.548E+03	1.202E+00	0.05%	2.513E+03	2.577E+03	2.513E+03	2.577E+03	1.177E+01	0.005
1987	2.676E+03	1.195E+00	0.04%	2.643E+03	2.704E+03	2.643E+03	2.704E+03	1.198E+01	0.004
1988	2.484E+03	1.190E+00	0.05%	2.451E+03	2.511E+03	2.451E+03	2.511E+03	1.231E+01	0.005
1989	2.414E+03	1.196E+00	0.05%	2.383E+03	2.441E+03	2.383E+03	2.441E+03	1.164E+01	0.005
1990	2.459E+03	1.228E+00	0.05%	2.429E+03	2.484E+03	2.429E+03	2.484E+03	1.112E+01	0.005
1991	2.404E+03	1.273E+00	0.05%	2.377E+03	2.428E+03	2.377E+03	2.428E+03	1.135E+01	0.005
1992	2.070E+03	1.356E+00	0.07%	2.045E+03	2.095E+03	2.045E+03	2.095E+03	1.190E+01	0.006
1993	1.958E+03	1.486E+00	0.08%	1.934E+03	1.984E+03	1.934E+03	1.984E+03	1.256E+01	0.006
1994	1.866E+03	1.667E+00	0.09%	1.843E+03	1.891E+03	1.843E+03	1.891E+03	1.387E+01	0.007
1995	1.978E+03	1.919E+00	0.10%	1.959E+03	2.003E+03	1.959E+03	2.003E+03	1.369E+01	0.007
1996	1.897E+03	2.252E+00	0.12%	1.879E+03	1.924E+03	1.879E+03	1.924E+03	1.589E+01	0.008
1997	1.731E+03	2.705E+00	0.16%	1.712E+03	1.757E+03	1.712E+03	1.757E+03	1.837E+01	0.011
1998	1.648E+03	3.338E+00	0.20%	1.625E+03	1.678E+03	1.625E+03	1.678E+03	2.264E+01	0.014
1999	1.470E+03	4.214E+00	0.29%	1.446E+03	1.508E+03	1.446E+03	1.508E+03	2.812E+01	0.019
2000	1.425E+03	5.412E+00	0.38%	1.400E+03	1.472E+03	1.400E+03	1.472E+03	3.431E+01	0.024
2001	1.380E+03	7.029E+00	0.51%	1.346E+03	1.440E+03	1.346E+03	1.440E+03	4.297E+01	0.031
2002	1.157E+03	9.282E+00	0.80%	1.118E+03	1.234E+03	1.118E+03	1.234E+03	5.716E+01	0.049
2003	1.072E+03	1.242E+01	1.16%	1.021E+03	1.178E+03	1.021E+03	1.178E+03	7.844E+01	0.073
2004	8.416E+02	1.682E+01	2.00%	7.712E+02	9.830E+02	7.712E+02	9.830E+02	1.067E+02	0.127
2005	8.419E+02	2.282E+01	2.71%	7.424E+02	1.039E+03	7.424E+02	1.039E+03	1.434E+02	0.170
2006	9.773E+02	3.056E+01	3.13%	8.379E+02	1.246E+03	8.379E+02	1.246E+03	2.021E+02	0.207
2007	1.189E+03	3.994E+01	3.36%	1.000E+03	1.542E+03	1.000E+03	1.542E+03	2.767E+02	0.233

2008	1.420E+03	5.049E+01	3.56%	1.162E+03	1.896E+03	1.162E+03	1.896E+03	3.636E+02	0.256
2009	1.716E+03	6.113E+01	3.56%	1.372E+03	2.333E+03	1.372E+03	2.333E+03	4.778E+02	0.278
2010	2.168E+03	6.966E+01	3.21%	1.721E+03	2.919E+03	1.721E+03	2.919E+03	6.003E+02	0.277
2011	2.783E+03	7.285E+01	2.62%	2.220E+03	3.648E+03	2.220E+03	3.648E+03	7.204E+02	0.259
2012	2.999E+03	7.210E+01	2.40%	2.327E+03	3.960E+03	2.327E+03	3.960E+03	8.394E+02	0.280
2013	3.202E+03	6.886E+01	2.15%	2.429E+03	4.254E+03	2.429E+03	4.254E+03	9.472E+02	0.296
2014	3.391E+03	6.321E+01	1.86%	2.524E+03	4.520E+03	2.524E+03	4.520E+03	1.041E+03	0.307
2015	3.563E+03	5.553E+01	1.56%	2.612E+03	4.752E+03	2.612E+03	4.752E+03	1.120E+03	0.314
2016	3.718E+03	4.638E+01	1.25%	2.694E+03	4.950E+03	2.694E+03	4.950E+03	1.184E+03	0.319
2017	3.855E+03	3.637E+01	0.94%	2.769E+03	5.115E+03	2.769E+03	5.115E+03	1.234E+03	0.320
2018	3.975E+03	2.606E+01	0.66%	2.838E+03	5.252E+03	2.838E+03	5.252E+03	1.271E+03	0.320
2019	4.079E+03	1.596E+01	0.39%	2.899E+03	5.364E+03	2.899E+03	5.364E+03	1.298E+03	0.318
2020	4.168E+03	6.409E+00	0.15%	2.955E+03	5.455E+03	2.955E+03	5.455E+03	1.315E+03	0.316
2021	4.244E+03	-2.337E+00	-0.06%	3.005E+03	5.527E+03	3.005E+03	5.527E+03	1.326E+03	0.312

Table 7.28.3.3.10. ASPIC projections with F_{MSY}. Absolute F.

TRAJECTORY OF ABSOLUTE FISHING MORTALITY RATE (BOOTSTRAPPED)

Year	Point estimate	Estimated bias	Relative bias	App. 80% lower CL	App. 80% upper CL	App. 50% lower CL	App. 50% upper CL	Inter-quartile range	Relative IQ range
1970	3.032E-01	1.974E-04	0.07%	2.993E-01	3.085E-01	2.993E-01	3.085E-01	1.773E-03	0.006
1971	2.382E-01	1.311E-04	0.06%	2.352E-01	2.422E-01	2.352E-01	2.422E-01	1.332E-03	0.006
1972	3.916E-01	1.973E-04	0.05%	3.867E-01	3.981E-01	3.867E-01	3.981E-01	2.188E-03	0.006
1973	3.670E-01	2.199E-04	0.06%	3.621E-01	3.735E-01	3.621E-01	3.735E-01	2.223E-03	0.006
1974	3.888E-01	3.044E-04	0.08%	3.830E-01	3.962E-01	3.830E-01	3.962E-01	2.722E-03	0.007
1975	2.538E-01	2.365E-04	0.09%	2.498E-01	2.588E-01	2.498E-01	2.588E-01	1.851E-03	0.007
1976	2.746E-01	2.585E-04	0.09%	2.703E-01	2.800E-01	2.703E-01	2.800E-01	2.073E-03	0.008
1977	2.427E-01	2.309E-04	0.10%	2.389E-01	2.474E-01	2.389E-01	2.474E-01	1.827E-03	0.008
1978	2.466E-01	2.249E-04	0.09%	2.428E-01	2.513E-01	2.428E-01	2.513E-01	1.832E-03	0.007
1979	2.453E-01	2.149E-04	0.09%	2.416E-01	2.497E-01	2.416E-01	2.497E-01	1.801E-03	0.007
1980	2.138E-01	1.704E-04	0.08%	2.107E-01	2.175E-01	2.107E-01	2.175E-01	1.501E-03	0.007
1981	2.113E-01	1.416E-04	0.07%	2.084E-01	2.147E-01	2.084E-01	2.147E-01	1.363E-03	0.006
1982	2.052E-01	1.088E-04	0.05%	2.024E-01	2.081E-01	2.024E-01	2.081E-01	1.232E-03	0.006
1983	2.814E-01	1.275E-04	0.05%	2.779E-01	2.852E-01	2.779E-01	2.852E-01	1.569E-03	0.006
1984	2.321E-01	8.787E-05	0.04%	2.292E-01	2.350E-01	2.292E-01	2.350E-01	1.194E-03	0.005
1985	2.949E-01	8.997E-05	0.03%	2.915E-01	2.985E-01	2.915E-01	2.985E-01	1.414E-03	0.005
1986	2.469E-01	6.241E-05	0.03%	2.441E-01	2.497E-01	2.441E-01	2.497E-01	1.127E-03	0.005
1987	3.722E-01	8.889E-05	0.02%	3.682E-01	3.763E-01	3.682E-01	3.763E-01	1.611E-03	0.004
1988	3.313E-01	8.209E-05	0.02%	3.277E-01	3.351E-01	3.277E-01	3.351E-01	1.449E-03	0.004
1989	2.852E-01	5.200E-05	0.02%	2.821E-01	2.884E-01	2.821E-01	2.884E-01	1.279E-03	0.004
1990	3.262E-01	3.965E-05	0.01%	3.228E-01	3.297E-01	3.228E-01	3.297E-01	1.466E-03	0.004
1991	4.618E-01	4.570E-05	0.01%	4.566E-01	4.669E-01	4.566E-01	4.669E-01	2.392E-03	0.005
1992	3.776E-01	2.674E-05	0.01%	3.728E-01	3.820E-01	3.728E-01	3.820E-01	2.284E-03	0.006
1993	3.742E-01	-6.175E-06	0.00%	3.691E-01	3.785E-01	3.691E-01	3.785E-01	2.566E-03	0.007
1994	2.669E-01	-5.198E-05	-0.02%	2.630E-01	2.697E-01	2.630E-01	2.697E-01	1.943E-03	0.007
1995	3.671E-01	-1.488E-04	-0.04%	3.615E-01	3.706E-01	3.615E-01	3.706E-01	2.967E-03	0.008
1996	4.217E-01	-2.805E-04	-0.07%	4.149E-01	4.260E-01	4.149E-01	4.260E-01	3.904E-03	0.009
1997	3.849E-01	-4.069E-04	-0.11%	3.782E-01	3.896E-01	3.782E-01	3.896E-01	4.708E-03	0.012
1998	4.555E-01	-7.365E-04	-0.16%	4.456E-01	4.620E-01	4.456E-01	4.620E-01	7.736E-03	0.017
1999	3.772E-01	-8.985E-04	-0.24%	3.661E-01	3.837E-01	3.661E-01	3.837E-01	8.270E-03	0.022
2000	3.800E-01	-1.272E-03	-0.33%	3.656E-01	3.875E-01	3.656E-01	3.875E-01	1.078E-02	0.028
2001	5.307E-01	-2.578E-03	-0.49%	5.028E-01	5.458E-01	5.028E-01	5.458E-01	2.217E-02	0.042
2002	4.364E-01	-3.004E-03	-0.69%	4.032E-01	4.546E-01	4.032E-01	4.546E-01	2.641E-02	0.061
2003	6.096E-01	-5.598E-03	-0.92%	5.374E-01	6.516E-01	5.374E-01	6.516E-01	6.111E-02	0.100
2004	3.718E-01	-3.787E-03	-1.02%	3.082E-01	4.127E-01	3.082E-01	4.127E-01	5.363E-02	0.144
2005	2.202E-01	-1.997E-03	-0.91%	1.742E-01	2.529E-01	1.742E-01	2.529E-01	4.072E-02	0.185
2006	1.657E-01	-1.146E-03	-0.69%	1.294E-01	1.943E-01	1.294E-01	1.943E-01	3.541E-02	0.214
2007	1.751E-01	-6.189E-04	-0.35%	1.323E-01	2.093E-01	1.323E-01	2.093E-01	4.114E-02	0.235
2008	1.515E-01	1.884E-04	0.12%	1.120E-01	1.858E-01	1.120E-01	1.858E-01	3.896E-02	0.257
2009	9.142E-02	5.197E-04	0.57%	6.738E-02	1.145E-01	6.738E-02	1.145E-01	2.419E-02	0.265
2010	5.227E-02	4.304E-04	0.82%	3.919E-02	6.560E-02	3.919E-02	6.560E-02	1.358E-02	0.260
2011	2.091E-01	1.722E-03	0.82%	1.568E-01	2.624E-01	1.568E-01	2.624E-01	5.431E-02	0.260
2012	2.091E-01	1.722E-03	0.82%	1.568E-01	2.624E-01	1.568E-01	2.624E-01	5.431E-02	0.260
2013	2.091E-01	1.722E-03	0.82%	1.568E-01	2.624E-01	1.568E-01	2.624E-01	5.431E-02	0.260

2014	2.091E-01	1.722E-03	0.82%	1.568E-01	2.624E-01	1.568E-01	2.624E-01	5.431E-02	0.260
2015	2.091E-01	1.722E-03	0.82%	1.568E-01	2.624E-01	1.568E-01	2.624E-01	5.431E-02	0.260
2016	2.091E-01	1.722E-03	0.82%	1.568E-01	2.624E-01	1.568E-01	2.624E-01	5.431E-02	0.260
2017	2.091E-01	1.722E-03	0.82%	1.568E-01	2.624E-01	1.568E-01	2.624E-01	5.431E-02	0.260
2018	2.091E-01	1.722E-03	0.82%	1.568E-01	2.624E-01	1.568E-01	2.624E-01	5.431E-02	0.260
2019	2.091E-01	1.722E-03	0.82%	1.568E-01	2.624E-01	1.568E-01	2.624E-01	5.431E-02	0.260
2020	2.091E-01	1.722E-03	0.82%	1.568E-01	2.624E-01	1.568E-01	2.624E-01	5.431E-02	0.260

Relative yields derived from an increase in F toward F_{MSY} will be clearly higher than the yields calculated with the status quo scenario (Figure 7.28.3.3.3).

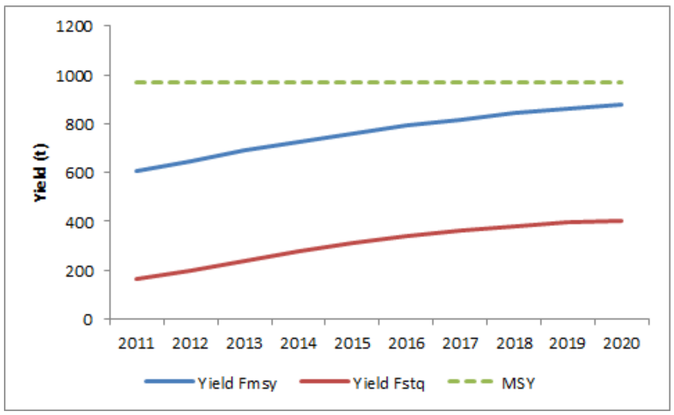


Fig. 7.28.3.3.3. Expected relative yields (in tons) obtained by keeping F at the current level or by increasing F in order to reach the F_{msy} value.

8 ToR G Quality and completeness of the official Mediterranean DCF data call

The STECF EWG 11-20 addressed the adjustements of data needs and quality for Mediterranean stocks fisheries and surveys in the 2012 Data Collection Framework (DCF). Within the DCF, Member States (MS) are legally bounded to deliver data according to deadlines defined in their National Plans, which are regularly revised by SGRN and approved by STECF. However, the deadlines are not currently harmonized between Member States (i.e. there are different dates for the different MS) and most importantly they are not harmonized with the dates of the end-users, the assessment working groups (i.e. data are not available at the time of the yearly assessment). Thus, EWG 11-20 recommends that, the deadlines of data delivering of the Mediterranean MS are analyzed in order to harmonize these between countries and with the periodicity of the assessment working groups.

EWG 11-20 recommends the different MS to agree on a harmonized time period required for data to be available for transmission to end-users. EWG 11-20 suggests, for all transversal and biological data collected, a time period of 6 months following the last day of the collection of data (i.e. last survey day or last calendar day for landings data); this time period should be respected by the data calls and the end users.

9 ToR H Assessment of fisheries management plan submitted by Spain and Slovenia

According to EU regulations, Member States are expected to adopt management plans for the different fisheries.

The plans shall include conservation reference points which allow the exploitation of stocks according to the MSY framework. The management plans shall also be established on the basis of the precautionary approach to fisheries management and take account of biological reference points recommended by the relevant scientific bodies.

The plans shall ensure the long term sustainable exploitation of the stocks and that the impact of fishing activities on the marine ecosystems is kept within sustainable levels.

The Management plans may incorporate any measure to limit fishing mortality and the environmental impact of fishing activities: limiting catches, fixing the number and type of fishing vessels authorized to fish, limiting fishing effort (e.g. number of fishing days), adopting technical measures (e.g. structure of fishing gears, fishing practices, areas/period of fishing restriction, minimum size, reduction of impact of fishing activities on marine ecosystems and non-target species), establishing incentives to promote more selective fishing and conduct pilot projects on alternative types of fishing management techniques.

STECF EWG 11-20 is requested to review the scientific basis for management plan(s) as required by the Mediterranean Regulation (C.R. (EC) No1967/2006), to evaluate its findings, to make appropriate comments, also with respect to the elements/measures included in the proposed management plan, and to advise whether the plan contains elements that account for:

1. the biological characteristics and the state of the exploited resources with reference in particular to low risk of stock collapse,
2. the fishing pressure and if concerned fisheries are duly described and expected to exploit the main target stocks in line with their production potentials. Advise whether the plan is expected to maintain or to revert fisheries productivity to higher levels in line with MSY or proxy and in which time frame.
3. pre-agreed harvesting control rules based either on catch limitation, fishing pressure or biomass levels
4. impact of fishing activities on marine environment (protected habitats and species)
5. size and/or species selectivity of the regulated fishing gears with particular attention to sizes and relative quantities of species mentioned in Annex III of the Mediterranean Regulation mechanisms of monitoring and review of the plans.

The STECF reviewed both management plans in written procedure and report is published on STECF-OWP-12-02.

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11 ANNEX I LIST OF PARTICIPANTS TO STECF EWG 11-20

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12 Annex II Overview of stock assessments performed during STECF MED meetings from 2008 to 2011

Table keys:

(1): F_{bar} and F_{msy} (F_{bar} and E_{msy}) correspond to the year when assessment was performed.

(2): Recent status according to the assessed stock exploitation and sustainable levels since 2009. Earlier assessments of are not considered as they may not necessarily be representative of the recent stock status.

(3): Empty cells signify no forecast of catch and stock size under various management options was performed.

noF = Assessment performed but not concluded.

noP = Assessment not performed.

YES = Forecast of catch and stock size under various management options performed.

No.	GSA	Common name	Species	F_{bar} / E_{bar} for small pelagic (1)				F_{msy} / E_{msy} for small pelagic (1)				Stock Status since 2009 (2)	Forecast (3)			
				2008	2009	2010	2011	2008	2009	2010	2011		2008	2009	2010	2011
1	1	Hake	*Merluccius merluccius*	noF	noF	noF	1.37	noF	noF	noF	0.21	overexploited				YES
2	1	Red mullet	*Mullus barbatus*	noF	noF	noF	1.79	noF	noF	noF	0.3	overexploited				YES
3	1	Pink shrimp	*Parapenaeus longirostris*	noF	noF	noF	noP	noF	noF	noF	noP	unknown				
4	1	Sardine	*Sardina pilchardus*	0.26	noP	0.3	noP	noF	noP	0.4	noP	sustainable	YES		YES	
5	1	Anchovy	*Engraulis encrasicolus*	1.82	noF	0.64	noP	noF	noF	0.4	noP	overexploited	YES		YES	
6	1	Blue and red shrimp	*Aristeus antennatus*	noP	noP	noP	1.32	noP	noP	noP	0.29	overexploited				
7	5	Hake	*Merluccius merluccius*	noF	noF	0.84	1.21	noF	noF	0.22	0.16	overexploited		YES	YES	YES
8	5	Red mullet	*Mullus barbatus*	noP	noP	1.08	noP	noP	noP	0.31	noP	overexploited			YES	
9	5	Pink shrimp	*Parapenaeus longirostris*	noP	noP	0.82	noP	noP	noP	0.31	noP	overexploited			YES	
10	5	Striped red mullet	*Mullus surmuletus*	noP	noP	0.76	0.55	noP	noP	0.29	0.26	overexploited			YES	YES
11	5	Norway lobster	*Nephrops norvegicus*	noP	noP	0.62	noP	noP	noP	0.42	noP	overexploited			YES	
12	6	Hake	*Merluccius merluccius*	0.7	1.5	0.99	1.3	0.19	0.16	0.2	0.11	overexploited	YES	YES	YES	YES
13	6	Red mullet	*Mullus barbatus*	0.7	noF	1.08	1.9	0.16	noF	0.74	0.38	overexploited			YES	YES
14	6	Pink shrimp	*Parapenaeus longirostris*	0.2	0.5	0.43	1	noF	0.2	noF	0.25	overexploited		YES		YES
15	6	Blue and red shrimp	*Aristeus antennatus*	noP	1.3	0.8	noP	noP	noF	noF	noP	unknown		YES		
16	6	Sardine	*Sardina pilchardus*	0.83	noP	0.8	noP	noF	noP	0.4	noP	overexploited	YES		YES	
17	6	Anchovy	*Engraulis encrasicolus*	1.17	noF	0.6	noP	noF	noF	0.4	noP	overexploited	YES		YES	
18	7	Hake	*Merluccius merluccius*	0.7	noF	0.92	1.43	0.22	noF	0.27	0.24	overexploited			YES	YES

19	7	Red mullet	*Mullus barbatus*	noF	noF	0.69	0.94	noF	noF	0.49	0.51	overexploited			YES	YES
20	7	Anchovy	*Engraulis encrasicolus*	0.23	noP	noP	noP	noF	noP	noP	noP	unknown				
21	8	Hake	*Merluccius merluccius*	noF	noF	noF	noP	noF	noF	noF	noP	unknown				
22	8	Red mullet	*Mullus barbatus*	noF	noF	noF	noP	noF	noF	noF	noP	unknown				
23	9	Hake	*Merluccius merluccius*	1.6	1.2	1.3	1.32	0.22	0.22	0.2	0.2	overexploited		YES	YES	YES
24	9	Red mullet	*Mullus barbatus*	0.86	0.97	0.73	0.59	0.42	0.58	0.62	0.47	overexploited		YES	YES	YES
25	9	Pink shrimp	*Parapenaeus longirostris*	0.6	0.5	0.5	0.29	1.3	0.7	0.7	0.7	sustainable		YES	YES	YES
26	9	Striped red mullet	*Mullus surmuletus*	noP	noP	noP	0.56	noP	noP	noP	0.31	overexploited				
27	9	Giant red shrimp	*Aristaeomorpha foliacea*	noP	noP	noP	1.05	noP	noP	noP	0.5	overexploited				YES
28	9	Blue and red shrimp	*Aristeus antennatus*	noP	noP	noP	0.62	noP	noP	noP	0.32	overexploited				YES
29	9	Norway lobster	*Nephrops norvegicus*	noP	0.36	0.45	0.34	noP	0.21	0.21	0.21	overexploited		YES	YES	YES
30	9	Spottail mantis shrimp	*Squilla mantis*	noP	noP	noP	1.24	noP	noP	noP	0.54	overexploited				YES
31	9	Poor cod	*Trisopterus minutus*	noP	noP	noP	noF	noP	noP	noP	noF	unknown				
32	9	Anchovy	*Engraulis encrasicolus*	noP	noP	0.75	1	noP	noP	0.4	0.4	overexploited				
33	9	Common Pandora	*Pagellus erythrinus*	noP	noP	0.26	0.63	noP	noP	0.13	0.48	overexploited				
34	9	Blackmouth catshark	*Galeus melastomus*	noP	noP	noP	0.35	noP	noP	noP	0.13	overexploited				
35	10	Hake	*Merluccius merluccius*	noF	0.55	0.72	0.63	noF	0.24	0.2	0.17	overexploited		YES	YES	YES
36	10	Red mullet	*Mullus barbatus*	0.65	noF	0.57	1.01	0.59	noF	0.42	0.4	overexploited			YES	YES
37	10	Pink shrimp	*Parapenaeus longirostris*	noF	noF	1.33	1.11	noF	noF	0.58	0.6	overexploited				YES
38	10	Giant red shrimp	*Aristaeomorpha foliacea*	noP	noF	noF	noP	noP	noF	noF	noP	unknown				
39	10	Blue and red shrimp	*Aristeus antennatus*	noP	noF	noF	noP	noP	noF	noF	noP	unknown				
40	10	Norway lobster	*Nephrops norvegicus*	noP	noF	noF	noP	noP	noF	noF	noP	unknown				
41	11	Hake	*Merluccius merluccius*	noF	1	0.98	0.37	noF	0.17	0.3	0.22	unknown			YES	YES
42	11	Red mullet	*Mullus barbatus*	noF	noF	1.34	noP	noF	noF	0.47	noP	overexploited		YES	YES	YES
43	11	Pink shrimp	*Parapenaeus longirostris*	noF	noF	noF	noF	noF	noF	noF	0.82	unknown				
44	11	Giant red shrimp	*Aristaeomorpha foliacea*	noP	noF	noF	0.98	noP	noF	noF	0.49	overexploited				
45	11	Blue and red shrimp	*Aristeus antennatus*	noP	noF	noF	noP	noP	noF	noF	noP	unknown				
46	11	Norway lobster	*Nephrops norvegicus*	noP	noF	noF	noP	noP	noF	noF	noP	unknown				
47	15-16	Hake	*Merluccius merluccius*	0.66	noF	0.62	noP	0.16	noF	0.15	noP	overexploited			YES	
48	15-16	Red mullet	*Mullus barbatus*	noF	noF	0.53	0.8	noF	noF	0.31	0.45	overexploited				
49	12-16	Pink shrimp	*Parapenaeus longirostris*	1.2	noF	0.98	noP	0.83	noF	0.9	noP	overexploited			YES	
50	15-16	Striped red mullet	*Mullus surmuletus*	noP	noP	noP	noF	noP	noP	noP	noF	unknown				
51	15-16	Giant red shrimp	*Aristaeomorpha foliacea*	noP	0.73	0.7	1.09	noP	0.35	0.3	0.4	overexploited		YES	YES	
52	15-16	Common Pandora	*Pagellus erythrinus*	noP	noP	noP	0.6	noP	noP	noP	0.3	overexploited				
53	15-16	Thorny skate	*Amblyraja radiata*	noP	noP	noP	noF	noP	noP	noP	noF	unknown				
54	16	Norway lobster	*Nephrops norvegicus*	noP	noF	noF	noP	noP	noF	noF	noP	unknown				
55	16	Blue and red shrimp	*Aristeus antennatus*	noP	noF	noF	noP	noP	noF	noF	noP	unknown				
56	16	Sardine	*Sardina pilchardus*	noP	0.22	0.23	0.17	noP	0.4	0.4	0.4	sustainable		YES		YES

57	16	Anchovy	*Engraulis encrasicolus*	noP	0.64	0.54	0.5	noP	0.4	0.4	0.4	overexploited	YES		
58	17	Hake	*Merluccius merluccius*	1.22	noF	0.6	noP	0.22	noF	0.33	noP	unknown			
59	17	Red mullet	*Mullus barbatus*	1.08	1.08	noF	noP	noF	noF	noF	noP	unknown			
60	17	Norway lobster	*Nephrops norvegicus*	noP	noP	noF	noP	noP	noP	noF	noP	unknown			
61	17	Sardine	*Sardina pilchardus*	0.48	0.45	noF	0.39	0.4	0.4	noF	0.4	sustainable			YES
62	17	Anchovy	*Engraulis encrasicolus*	0.28	0.4	noF	noF	0.4	0.4	0.4	0.4	unknown			
63	17	Common sole	*Solea solea*	noP	1.35	1.36	1.2	noP	0.26	0.26	0.26	overexploited	YES	YES	YES
64	18	Hake	*Merluccius merluccius*	noF	noF	0.95	0.86	noF	noF	0.22	0.21	overexploited		YES	YES
65	18	Red mullet	*Mullus barbatus*	noF	noF	noF	noP	noF	noF	noF	noP	unknown			
66	18	Pink shrimp	*Parapenaeus longirostris*	noF	noF	noF	noP	noF	noF	noF	noP	unknown			
67	18	Norway lobster	*Nephrops norvegicus*	noP	noF	noF	noP	noP	noF	noF	noP	unknown			
68	19	Hake	*Merluccius merluccius*	noF	noF	noF	noP	noF	noF	noF	noP	unknown			
69	19	Red mullet	*Mullus barbatus*	noF	noF	noF	noP	noF	noF	noF	noP	unknown			
70	19	Pink shrimp	*Parapenaeus longirostris*	noF	noF	noF	noP	noF	noF	noF	noP	unknown			
71	19	Giant red shrimp	*Aristaeomorpha foliacea*	noP	noF	noF	noP	noP	noF	noF	noP	unknown			
72	20	Hake	*Merluccius merluccius*	noF	noF	noF	noP	noF	noF	noF	noP	unknown			
73	20	Red mullet	*Mullus barbatus*	noF	noF	noF	noP	noF	noF	noF	noP	unknown			
74	20	Sardine	*Sardina pilchardus*	noP	noP	0.46	noP	noP	noP	0.4	noP	outdated		YES	
75	20	Anchovy	*Engraulis encrasicolus*	noP	noP	0.41	noP	noP	noP	0.4	noP	outdated		YES	
76	22	Sardine	*Sardina pilchardus*	0.42	0.41	0.41	0.48	0.4	0.4	0.4	0.4	outdated	YES		YES
77	22	Anchovy	*Engraulis encrasicolus*	0.32	0.36	0.36	0.38	0.4	0.4	0.4	0.4	outdated	YES		YES
78	22-23	Hake	*Merluccius merluccius*	noF	noF	noF	noP	noF	noF	noF	noP	unknown		YES	
79	22-23	Red mullet	*Mullus barbatus*	noF	noF	noF	noP	noF	noF	noF	noP	unknown		YES	
80	22-23	Pink shrimp	*Parapenaeus longirostris*	noF	noF	noF	noP	noF	noF	noF	noP	unknown		YES	
81	22-23	Striped red mullet	*Mullus surmuletus*	noP	noP	noF	noP	noP	noP	noF	noP	unknown		YES	
82	25	Red mullet	*Mullus barbatus*	noF	0.84	0.84	noP	noF	0.22	0.22	noP	overexploited	YES		
83	25	Picarel	*Spicara smaris*	noP	noP	noP	0.08	noP	noP	noP	0.31	sustainable			YES

13 ANNEX III EXAMPLE OF FLR SCRIPT USED FOR SHORT AND MEDIUM TERM FORECASTING

```
# Example code used for Assessment, Reference Points and Short and Medium term forecasting with
Hake GSA 9
# STECF EWG 11-20, January 2012
# Author= Finlay Scott
# Updated: Thursday 19/01/12
# New fishing scenario added for LTF
#*******************************************************************************

# These packages are for R-2.14.1
pkg_dir <- c("C:/Projects/STECF/SGMED/Jan_2012/FLR_packages_R2-14.1/")
pkg_list <- list("FLCore_2.5.0","FLAssess_2.5.0","FLXSA_2.5", "FLash_2.5.0",
            "FLBRP_2.5.0", "ggplotFL_0.1", "FLAdvice_1.0")
lapply(pkg_list, function(x) install.packages(paste(pkg_dir,x,".zip",sep="")))

#*******************************************************************************
# Load the libraries
library(FLCore); library(FLAssess);library(FLXSA);library(FLash);library(FLBRP);library(FLAdvice)
#*******************************************************************************
# First we rerun the assessment from the last meeting
# Read the raw data into an FLStock object
data.dir <- "c:/Projects/STECF/SGMED/Jan_2012/Hake_example/xsa2011b"
hke.stk <- readFLStock(paste(data.dir,"HK010.IND",sep="/"), no.discards=TRUE)

# Set the harvest units, fbar range and plus group age
units(harvest(hke.stk))<-"f"
range(hke.stk)["minfbar"] <- 2
range(hke.stk)["maxfbar"] <- 4
hke.stk <- setPlusGroup(hke.stk, 5)
# Read in the tuning data
hke.idx <- readFLIndices(paste(data.dir,"HK010Tun-standard.DAT",sep="/"))

#*******************************************************************************
# Perform assessment
# Set the control objext
xsa_control <- FLXSA.control(x=NULL, tol=1e-09, maxit=30, min.nse=0.3, fse=1.0,
            rage=1, qage=6, shk.n=TRUE, shk.f=TRUE, shk.yrs=2, shk.ages=2,
            window=100, tsrange=20, tspower=3, vpa=FALSE)
# Perform the XSA and put the results back into the stock object
hke.stk <- hke.stk + FLXSA(hke.stk,hke.idx, xsa_control)


#*******************************************************************************
# Fit stock recruitment relationship (SRR)
# Fit two different relationships, with two different steepness levels, 0.75 and 1
# (A steepness of 1 is equivalent to a mean recruitment)
# Steepness of 0.75
srr075 <- fmle(as.FLSR(hke.stk, model = "bevholtSV"), fixed = list(s = 0.75))
# Steepness of 1
srr1 <- fmle(as.FLSR(hke.stk, model = "bevholtSV"), fixed = list(s = 1))
# Take a look at the fits
plot(srr075)
plot(srr1)
```

```
#*****************************************************************************
# Get reference points
# To get the reference points you can use the FLBRP package
hke.brp.075 <- brp(FLBRP(hke.stk, sr = ab(srr075)))
hke.brp.1 <- brp(FLBRP(hke.stk, sr = ab(srr1)))
# An example about the assumptions that have been made:
# The equilibrium stock weight is:
stock.wt(hke.brp.075)
# Mean of last three years of original stock object
apply(stock.wt(hke.stk)[,ac(2008:2010)], c(1,3:6), mean)
# You can change these assumptions if you want using the arguments
# biol.nyears, fbar.nyears and sel.nyears, as detailed in the draft FLBRP manual
# For example, using the argument biol.nhyears:
hke.brp.test <- brp(FLBRP(hke.stk, sr = ab(srr075), biol.nyears=4))
# The stock weights are now averaged over 4 years
stock.wt(hke.brp.test)
apply(stock.wt(hke.stk)[,ac(2007:2010)], c(1,3:6), mean)
# We can now get the reference points
refpts(hke.brp.075)
refpts(hke.brp.1)
# So F at F0.1 can be accessed using
refpts(hke.brp.075)["f0.1","harvest"]
# and yield at F0.1
refpts(hke.brp.075)["f0.1","yield"]
# etc.

#*****************************************************************************
# Set up the future for the projections (priming)
# You need to consider what the future will look like in terms of future stock weights, maturity, natural mortality etc.
# There a couple of ways of doing this with FLR.  Here we will use the window(stock, FLBRP) method.
# This sets up your future stock so it is consistent with the assumptions you made about the reference points.
#This means that if you project forward using the estimated Fmsy, you should get a yield equal to MSY.
# If you don't have an FLBRP object then you can use the stf() method which does something very similar.
# Here we exend by only 3 years (i.e. a short term forecast)
hke.stf = window(hke.stk, end = 2013, FLBRP=hke.brp.075)
# Original stock
summary(hke.stk)
# Extended stock - note the change in years
summary(hke.stf)

# The future weights, selectivity etc. should be the same as in the FLBRP object,
# ensuring that our assumptions are consistent with the SRR (if any) and
# the reference points..
stock.wt(hke.stf)
stock.wt(hke.brp.075)
# We have not projected forward so we have no stock.n
stock.n(hke.stf)
# However, we have made an assumption about the future harvest rates
# The harvest rates have been set as the mean of the last 3 years
# and then rescaled so that the Fbar is 1
harvest(hke.stf)
fbar(hke.stf)
# To set up a long term projection we can simply change the end year
hke.ltf = window(hke.stk, end = 2020, FLBRP=hke.brp.075)
```

```
summary(hke.ltf)
#********************************************************************************
# Running a short term forecast (STF)

# Having primed our stock for projection , we can perform the projections using the fwd() method.
# A SRR is not generally used in a short term projection. Instead future recruitment is assumed to be constant.
# It is often assumed that the recruitment will be the mean of the last few years
# (this can be arithmetic or geometric mean).

# We also need to set some future fishing mortalities too.  Here F in 2011 is assumed to be the same F status quo
# Your Fstatus quo will depend on the recent F history. # Normally F status quo is set as the mean Fbar of the
last 3 years.
# However, if there is a trend then you may want to set F status quo as  F in the last year (the Fbar will be the
same as the last year,
# but the harvest rates at age will still be a function of the mean of the last few years)

# A range of different fishing mortality scenarios for 2012 and 2013 are set  For each scenario, the stock is
projected, and the results recorded.
# (The impact of F in 2013 is not realised until 2014 so it doesn't really matter what the value is).

# We need to set up a couple of objects to control the projection
# The constant future recruitment is here set as the arithmetic mean of the last 3 years (it doesn't have to be)
futureRec <- mean(rec(hke.stf)[,ac(2008:2010)])

# F status quo is set as the arithmetic mean of the last 3 years
Fstatusquo <- mean(fbar(hke.stf)[,ac(2008:2010)])
# However, if there is a recent trend in F then you may want to set Fstatusquo
# as the same in the final year e.g.
Fstatusquo <- c(fbar(hke.stf)[,ac(2010)])
#********* Slightly different bit follows 1430 ***********
# Each F scenario needs to be set up as a seperate FLQuant object
# and then put together into a list of FLQuants objects
# Future constant F scenarios are F = 0 * Fstatusquo , to F = 2 * Fstatusquo in 0.2 steps
# F = F0.1 is included as an additional scenario
Ffactor <- seq(from = 0, to = 2, by = 0.2)
Fscenarios <- Fstatusquo * Ffactor
# Get F0.1 from the BRP object
F01 <- refpts(hke.brp.075)["f0.1","harvest"]
# Add this to the F scenarios
Fscenarios <- c(Fscenarios,F01)
#************ End of slightly different bit ****************
# We now need to put these scenarios into individual FLQuant objects  F in 2011 is the same for all scenarios
# Set up empty FLQuant for the future years F
Fq <- FLQuant(NA, dimnames=list(year=2011:2013))
# Set futureF in 2011 as Fstatusquo
Fq[,"2011"] <- Fstatusquo
# Set up FLQuants object with a different FLQuant for each different F scenario
Fqs <- FLQuants(mlply(Fscenarios,function(x){Fq[,ac(2012:2013)] <- x; return(Fq)}))
# Need to name all of the FLQuant scenarios as "f"
names(Fqs) <- rep("f",length(Fscenarios))

# Now we can run the projections using the fwd() method
# Each projection is stored as an FLStock object inside an FLStocks object
#***** maxF has been increased **********
hke.stfs <- fwd(hke.stf, ctrl=Fqs, sr = list(model = "mean", params=FLPar(futureRec)), maxF=5)
class(hke.stfs)
```

```
# Quick check that the harvest rates are OK
harvest(hke.stfs[[2]])
fbar(hke.stfs[[2]])
plot(hke.stfs)
#Make a table of the results (landings, ssb, relative landings, relative ssb)
# Function to make the results table
# EDITED TO BE CONSISTENT WITH LAST YEAR
table_func <- function(stk){
  data.frame(
        fbar = c(fbar(stk)[,ac(2012)]),
        catch_2010 = c(catch(stk)[,ac(2010)]),
        catch_2011 = c(catch(stk)[,ac(2011)]),
        catch_2012 = c(catch(stk)[,ac(2012)]),
        catch_2013 = c(catch(stk)[,ac(2013)]),
        # catch in 2012 relative to 2010
        relative_catch_2012_to_2010 = c(100 * ((catch(stk)[,ac(2012)] - catch(stk)[,ac(2010)]) /
catch(stk)[,ac(2010)])),
        # SSB in 2012 - 2013
       ssb_2011 = c(ssb(stk)[,ac(2012)]),
       ssb_2012 = c(ssb(stk)[,ac(2012)]),
       ssb_2013 = c(ssb(stk)[,ac(2013)]),
       # SSB in 2013 relative to 2012
       relative_ssb_2013_to_2012 = c(100 * ((ssb(stk)[,ac(2013)] - ssb(stk)[,ac(2012)]) / ssb(stk)[,ac(2010)])))
}

# Apply the table function to get our results
results_table <- ldply(hke.stfs,table_func)
# Get rid of the X1 column
results_table <- results_table[,-1]
# Add on the Ffactor
results_table <- cbind(Ffactor = c(Ffactor, NA), results_table)

#******************************************************************************
# Long term projections
# Here we project until 2020 with 4 different scenarios and include stochasticity from the recruitment residuals
# (assuming you have them - if you don't have an SRR then you will need to adjust the following code and
ignore the bits about residuals)
# The F in 2011 is assumed to be Fstatusquo
# The 3 scenarios:
# 1) constant F = F0.1
# 2) 10% reduction in F per annum
# 3) Hit F = F0.1 by 2015, then fix at F = F0.1
# 4) Linear decrease in F to hit F = F0.1 in 2020
# Recruitment should be a constant (perhaps a mean) or from an SRR

# First set up an FLQuant of residuals from the SRR
nyears <- 10
niters  <- 500

# Setting up residuals based on the fitted SRR
srrDev  <- FLQuant(sample(c(residuals(srr075)),
            nyears*niters, replace=T),
            dimnames=list(year=2011:2020,
            iter=1:niters))
```

```
# If you don't have enough years in your stock recruitment relationship
# then you can artificially generate residuals by assuming that they are
# randomly selected from a log normal distribution with a chosen standard deviation
srr_sd_residuals <- 0.25
srrDev  <- log(FLQuant(rlnorm(nyears*niters,mean = 0, sd = srr_sd_residuals),
         dimnames=list(year=2011:2020,
         iter=1:niters)))

# Propagate the stock object
hke.ltf.niters  <- propagate(hke.ltf,niters)

# Now set up 3 FLQuant objects with our desired F scenarios based on Fsq
# As before, Fstatusquo is set as the arithmetic mean of the last 3 years
Fstatusquo <- mean(fbar(hke.ltf)[,ac(2008:2010)])
# However, as before, if there is a recent trend in F then you may want to set Fstatusquo
# as the same in the final year e.g.
Fstatusquo <- c(fbar(hke.ltf)[,ac(2010)])

# 1) constant F0.1
F01 <- c(refpts(hke.brp.075)["f0.1","harvest"])
constantF01 <- FLQuant(F01,dimnames=list(year=2011:2020))
# set F in 2011 as Fstatusquo
constantF01[,ac(2011)] <- Fstatusquo
# 2) Decrease from Fstatusquo by 10% pa
Fdecrease10 <- FLQuant(Fstatusquo * 0.9^(0:9),dimnames=list(year=2011:2020))
# 3) Decrese from Fstatusquo to F0.1 by 2015, then constant F0.1
FsqtoF01_2015 <- FLQuant(c(seq(from=Fstatusquo, to = F01, length = 5),rep(F01,5)),
 dimnames=list(year=2011:2020))
# 4) Decrease from Fstatusquo to F0.1 by 2020
FsqtoF01_2020 <- FLQuant(seq(from=Fstatusquo, to = F01, length = 10),
 dimnames=list(year=2011:2020))

# Put all these into an FLQuants
LTFFs <- FLQuants(f = constantF01, f = Fdecrease10,
        f = FsqtoF01_2015, f = FsqtoF01_2020)

# Project forward using fwd() to give 3 FLStock objects inside an FLStocks object
# Note that we include the residuals for stochastic recruitment
hke.ltf.niters <- fwd(hke.ltf.niters, ctrl=LTFFs, sr= list(model = "bevholt", params = params(ab(srr075))),
       sr.residuals=exp(srrDev), sr.residuals.mult=T)

# Plot them up all together
plot(hke.ltf.niters)

# Or individually, e.g.
plot(hke.ltf.niters[[1]])
plot(hke.ltf.niters[[2]])
plot(hke.ltf.niters[[3]])
plot(hke.ltf.niters[[4]])

#**************************************************************
```

14 LIST OF BACKGROUND DOCUMENTS

Background documents are published on the EWG 11-20 meeting's web site on:

https://stecf.jrc.ec.europa.eu/meetings/2011

List of background documents:

1. EWG 11-20 – Doc 1 – Declarations of invited and JRC experts.
2. EWG 11-20 – Doc 2 – STECF Opinion by Written Procedure for evaluations of Slovenian and Spanish Management Plans (STECF-OWP-12-02).

European Commission

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Abstract

The Expert Working Group meeting of the Scientific, Technical and Economic Committee for Fisheries EWG 11-20 was held from 16 – 20 January in Madrid, Spain, to assess the status of demersal and small pelagic stocks in the Mediterranean Sea against the proposed FMSY reference point and to carry out short and medium term forecasts. The report was reviwed and adopted by the STECF during its 39th plenary held from 16 to 20 April 2012 in Brussels (Belgium).

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The Scientific, Technical and Economic Committee for Fisheries (STECF) has been established by the European Commission. The STECF is being consulted at regular intervals on matters pertaining to the conservation and management of living aquatic resources, including biological, economic, environmental, social and technical considerations.

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